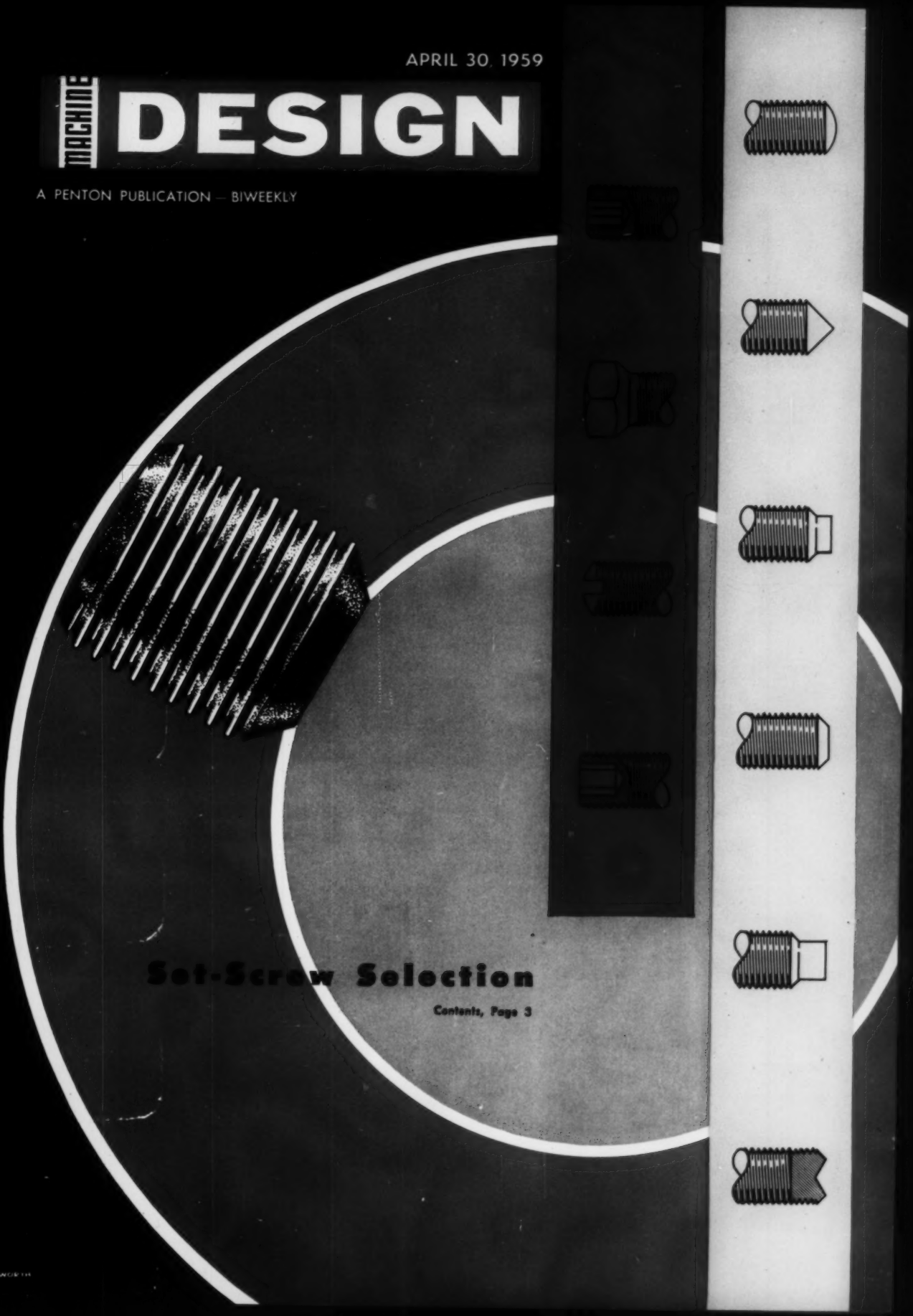
APRIL 30, 1959

MACHINE DESIGN

A PENTON PUBLICATION — BIWEEKLY



Set-Screw Selection

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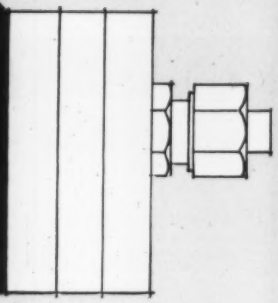
off-the-shelf pumps just right for your requirements



Whatever you want in a pump – for hydraulics, for flow or process control, there is likely to be an Eastern ready-made unit . . . made-to-order for your needs.

CAN YOU USE THESE PUMP FEATURES:

- ☐ corrosion resistant construction for chemical solutions?
- ☐ ability to handle organic and inorganic fluids at various temperatures with flows up to 70 GPM, pressures to 65 psig?
- ☐ available with open, enclosed or explosion proof motors?
- ☐ compact lightweight units with or without motor?
- ☐ high efficiencies in handling hydraulic oil, fuel and lubricants at high pressures?
- ☐ flow rates from 0.1 to 9.8 GPM, pressures from 0 to 1500 PSI?
- ☐ self-priming operation with non-lubricating liquids?
- ☐ high pressure outputs with small, low power units... and no contamination of fluid?
- ☐ flow rates from ½ GPM to 5½ GPM, pressures from 30 to 200 PSI?

An EASTERN CENTRIFUGAL PUMP MIGHT BE JUST RIGHT FOR YOU!

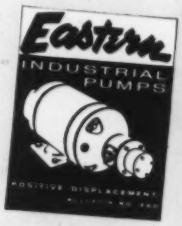
Write for Bulletin 120.

Look into EASTERN HYDRAULIC PUMPS!

Write for Bulletin 810

Get to know more about EASTERN POSITIVE DISPLACEMENT PUMPS!

Write for Bulletin 220.



These useful brochures contain full specifications on the complete line in each category, including performance data and tables. They will be sent to you at no obligation whatever. Write Department R.

EASTERN INDUSTRIES PUMP DIVISION®

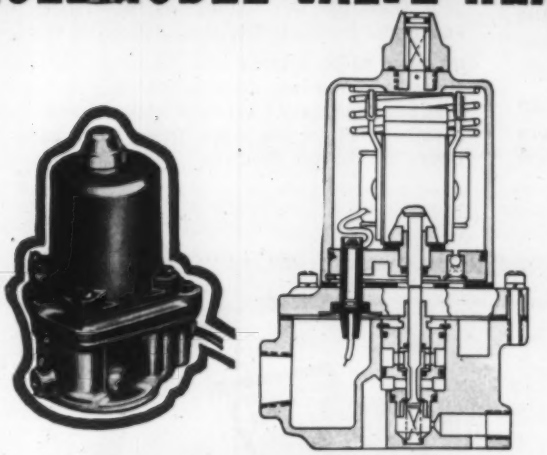
EASTERN INDUSTRIES, INC.

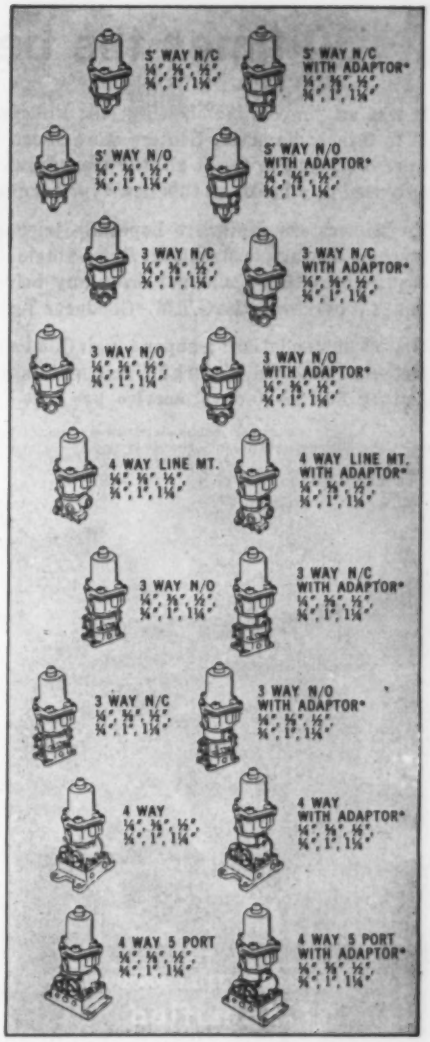
100 SKIFF STREET, HAMDEN 14, CONN.

Circle 401 on Page 19

a basic Ross valve building block

GOLDMODEL VALVE HEAD

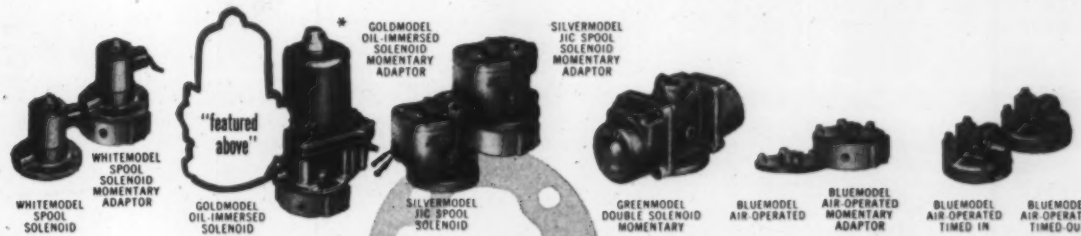



5 WAY N/C
5 WAY N/C WITH ADAPTOR*
5 WAY N/O
5 WAY N/O WITH ADAPTOR*
3 WAY N/C
3 WAY N/C WITH ADAPTOR*
3 WAY N/O
3 WAY N/O WITH ADAPTOR*
4 WAY LINE MT.
4 WAY LINE MT. WITH ADAPTOR*
3 WAY N/O
3 WAY N/C WITH ADAPTOR*
3 WAY N/C
3 WAY N/O WITH ADAPTOR*
4 WAY
4 WAY WITH ADAPTOR*
4 WAY 5 PORT
4 WAY 5 PORT WITH ADAPTOR*

OIL IMMERSED SOLENOID

- **The finest achievement in solenoid heads**
- **JIC**
- **Over 50 million cycles in tests**
- **Lightning fast**

Modular construction is brought to the air valve field to give you the effect of a great valve inventory without stocking a great number of valves. Stock just one of these Goldmodel heads and you have the finest solenoid actuator obtainable for any one of the 54 Skyline bodies. This is the head designed especially for those uses where dependable performance and very long life must supersede all other considerations. The dustproof solenoid is the very finest and is immersed in oil to run cool and stay young. Write for bulletin 318.



"every head meets every body at this gasket"

ALL SKYLINE HEADS AND BODIES ARE BUILDING BLOCKS TO GIVE YOU MANY VALVES FROM A FEW HEADS AND BODIES

STRAIGHTWAY NORMALLY OPEN NORMALLY CLOSED
3 WAY NORMALLY OPEN NORMALLY CLOSED
4 WAY
3 WAY NORMALLY OPEN NORMALLY CLOSED
4 WAY
4 WAY 5 PORT

STAY AHEAD MODERNIZE

ROSS OPERATING VALVE COMPANY

109 EAST GOLDEN GATE AVE. • DETROIT 3, MICH.

Circle 404 on Page 19

30 times the belt-life on belt-wrecking job

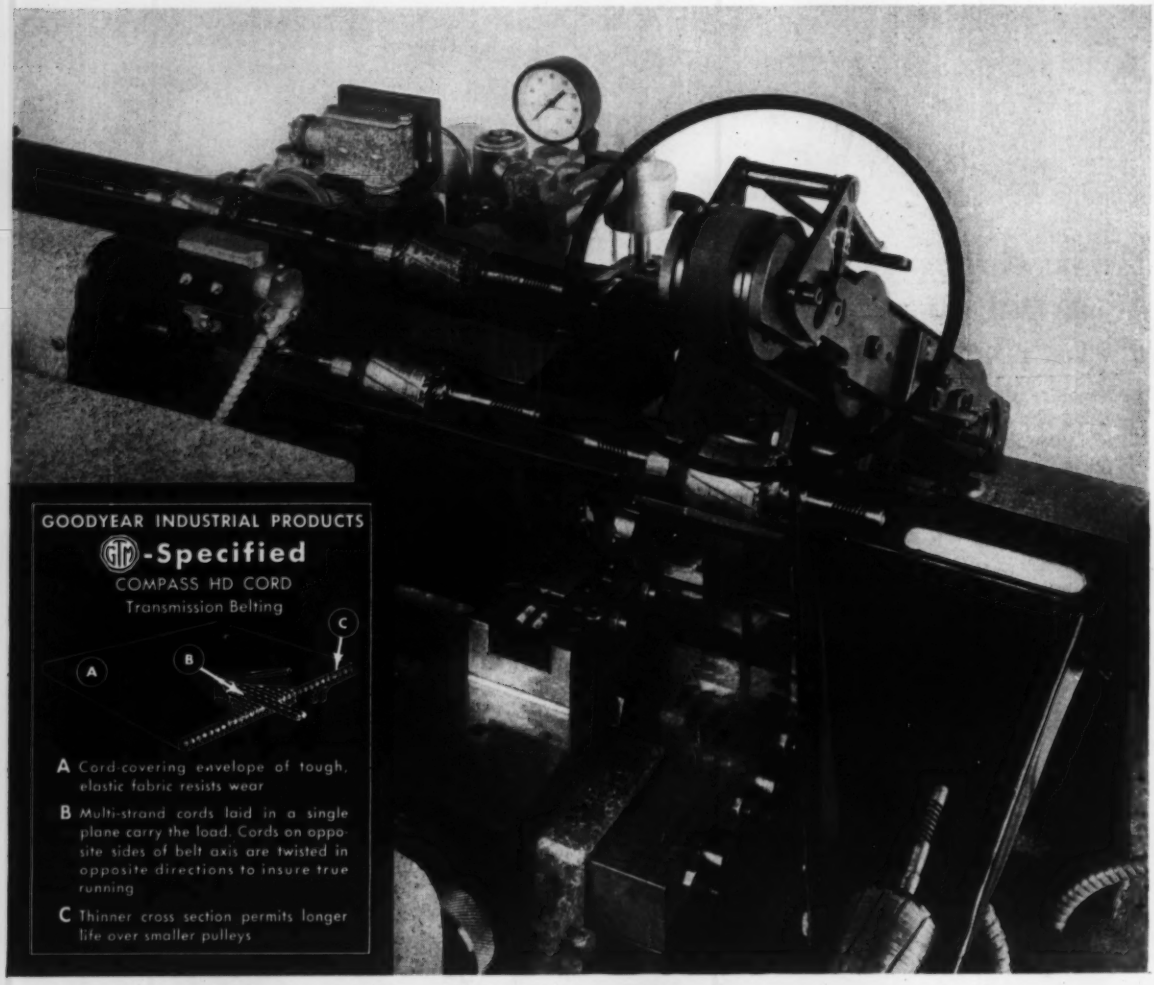
It was an "impossible" belting job: Pulleys were only 2- to 3-inch diameter. Centers were short. Conditions were oily. And to top it all, the transmission belt was also used as a brake on this new-type turning machine.

Its Midwestern designers hopefully tried out several types of belting construction. But a single day was the best service they could get from any belt—until they talked it over with the G.T.M.–Goodyear Technical Man.

His recommendation: a super-tough COMPASS HD CORD belt. And how did it work? Users of this machine are getting 30- to 60-days' service per belt – even when the machine is turning out 800 commutators an hour.

And that's one more case where the G.T.M. has supplied important help in getting a good new idea off the ground. If you'd like to turn loose his famed problem-solving ability on a project of yours, contact him through your Goodyear Distributor—or by writing Goodyear, Industrial Products Division, Akron 16, Ohio.

IT'S SMART TO DO BUSINESS with your Goodyear Distributor. He can give you fast, dependable service on Hose, V-Belts, Flat Belts and many other industrial rubber and nonrubber supplies. Look for him in the Yellow Pages under "Rubber Goods" or "Rubber Products."


GOODYEAR INDUSTRIAL PRODUCTS
GM-Specified
COMPASS HD CORD
Transmission Belting
A
B
C
A Cord-covering envelope of tough, elastic fabric resists wear
B Multi-strand cords laid in a single plane carry the load. Cords on opposite sides of belt axis are twisted in opposite directions to insure true running
C Thinner cross section permits longer life over smaller pulleys

COMPASS TRANSMISSION BELTS BY

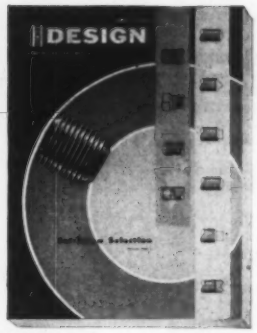
GOODYEAR

THE GREATEST NAME IN RUBBER

Compass—T. M. The Goodyear Tire & Rubber Company, Akron, Ohio

Watch "Goodyear Theater" on TV every other Monday evening.

Circle 405 on Page 19



Front Cover: Set-screw heads and points, plus a king-size set screw holding a part on a shaft, form the basis for George Farnsworth's cover design. Article by Francis R. Kull on Page 100 tells how to select set screws in design.

April 30, 1959

Almost-Human Engineering 22

NEWS REPORT—A new race of robots performs human functions in dangerous jobs.

Starting an Engineering Library 94

GLORIA EVANS—The case for setting up a centralized source of technical literature and reference information to serve the engineering department.

Set-Screw Selection 100

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MACHINE DESIGN

April 30, 1959
Volume 31 — No. 9

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NASA reports significant progress in design of Mercury man-in-space capsule—flexible plastic magnets can be extruded in any shape—"unitized" electric motors have "glued on" end bells—new extrusion technique squirts cold aluminum at right angles—rivet-like welds "button" metal sheets together—Pyroceram journal bearings pass heat and acid tests—all-aluminum car engines may have cylinder walls metallized by sprayed-on steel.

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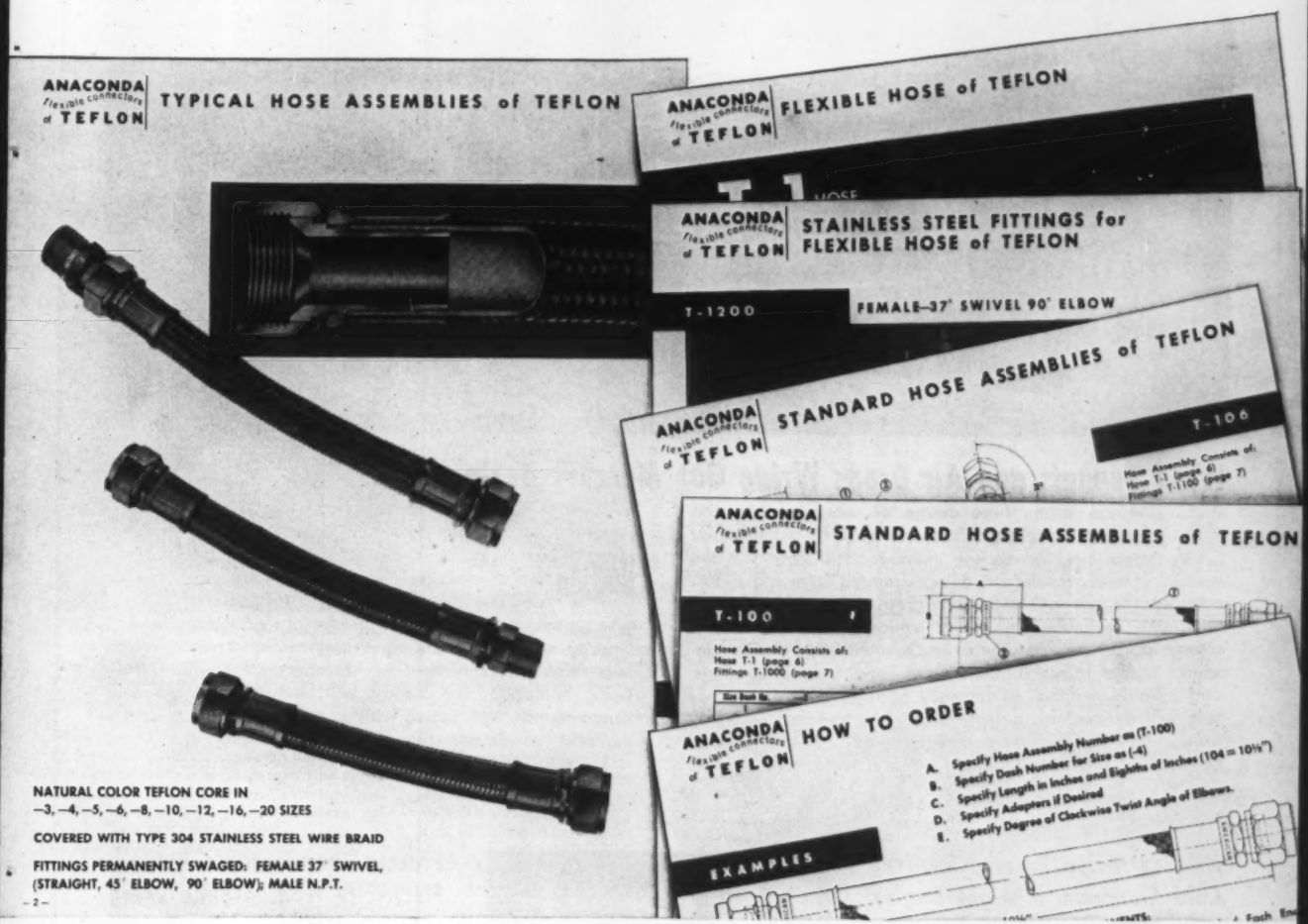
NEW CATALOG

. . . ON ANACONDA FLEXIBLE CONNECTORS OF TEFLON*


ANACONDA Flexible connectors of TEFLON
TYPICAL HOSE ASSEMBLIES of TEFLON
NATURAL COLOR TEFLON CORE IN
–3, –4, –5, –6, –8, –10, –12, –16, –20 SIZES
COVERED WITH TYPE 304 STAINLESS STEEL WIRE BRAID
FITTINGS PERMANENTLY SWAGED: FEMALE 37° SWIVEL,
(STRAIGHT, 45° ELBOW, 90° ELBOW); MALE N.P.T.
– 2 –
ANACONDA Flexible connectors of TEFLON
FLEXIBLE HOSE of TEFLON
T-1 HOSE
ANACONDA Flexible connectors of TEFLON
STAINLESS STEEL FITTINGS for FLEXIBLE HOSE of TEFLON
T-1200
FEMALE–37° SWIVEL 90° ELBOW
ANACONDA Flexible connectors of TEFLON
STANDARD HOSE ASSEMBLIES of TEFLON
T-106
Hose Assembly Consists of:
Hose T-1 (page 6)
Fittings T-1100 (page 7)
ANACONDA Flexible connectors of TEFLON
STANDARD HOSE ASSEMBLIES of TEFLON
T-100
Hose Assembly Consists of:
Hose T-1 (page 6)
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ANACONDA Flexible connectors of TEFLON
HOW TO ORDER
A. Specify Hose Assembly Number as (T-100)
B. Specify Dash Number for Size as (-4)
C. Specify Length in Inches and Eighths of Inches (104 = 10½")
D. Specify Adapters if Desired
E. Specify Degree of Clockwise Twist Angle of Elbows.
EXAMPLES

Hose assemblies of Teflon, like those illustrated above, were designed to help meet tough problems—temperature extremes, corrosion, high pressure in conveying chemicals, searching liquids, fuel, oils, oxygen, steam—or in hydraulic and conduit applications. A standard assembly may handle your job, help you cut costs. If not, our laboratory and test facilities, as well as engineering services, are available to help in design and development of hose assemblies for special applications. Let us show you how we can help you handle tough problems with Anaconda Flexible Connectors of Teflon. Send for catalog today. 59126

*Teflon is a DuPont trademark for TFE—fluorocarbon resin

WHEREVER CONNECTORS MUST MOVE

ANACONDA® METAL HOSE

Circle 406 on Page 19

An easy-to-use 16-page book with complete data, drawings, photos

Anaconda Metal Hose Division
The American Brass Company MD
Waterbury 20, Conn.

Please send me your free 16-page catalog of Anaconda Flexible Connectors of Teflon, No. TC-101

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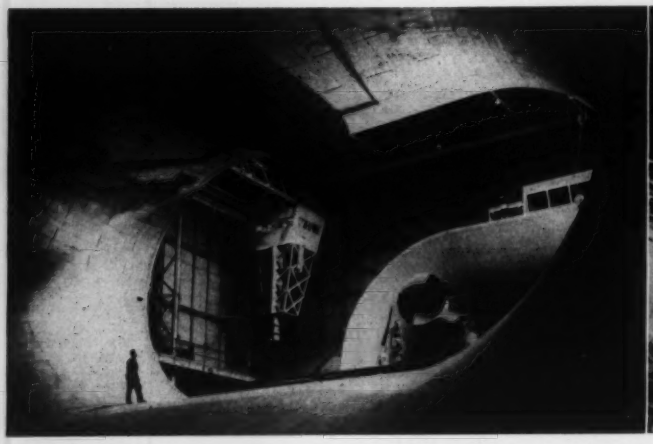
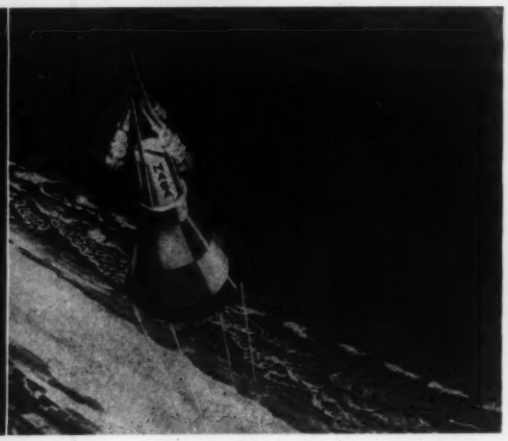
ENGINEERING NEWS





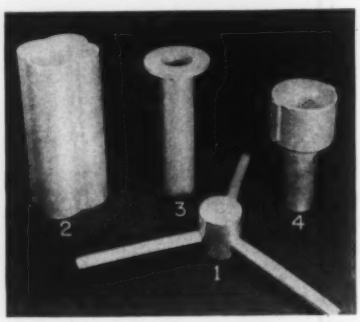
Wind Tunnels and Air Drops Wring Out Mercury Design

Major progress in the final design of subsystems for the Mercury man-in-space capsule is reported by scientists at NASA laboratories across the country. Full-scale two-ton models of the capsule are being dropped from big C-130 transport planes at NASA's Wallops Island facilities to determine optimum altitude at which to deploy the recovery parachute, aerodynamic characteristics during descent, impact forces in both water and ground landings, and reliable methods of recovery after landing. The capsule will descend at the rate of 30 fps, and various crushable materials, including honeycombed arrangements of corrugated plastic and aluminum, are being evaluated as a possible means of absorbing landing shock. Full-scale windtunnel at Langley Research Center, left, is being used to establish flight behavior of the capsule and re-entry heat transfer. Tunnel tests cover the velocity spectrum from several miles per hour to Mach 18 (11,000 mph). Capsule models are also placed on the tips of rockets for full-velocity study of tumbling characteristics, re-entry dynamics, and afterbody heating. Escape system, right, is also being finalized. The capsule will be fitted with pylon arrangement on top, tipped with an escape rocket. If booster malfunctions at any time from pad to orbit, the escape rocket can be triggered to free capsule from booster.

New Extrusion Process Squirts Cold Aluminum at Right Angles

PITTSBURGH — Strong, high-density aluminum parts with intricate lateral configurations are made by a new extrusion process at Alcoa. Called lateral impact extrusion, the process forces metal to flow in a direction perpendicular to the motion of the punch. Previous extrusions flowed axially — either up around the punch, or down into the die.

Faucet handles and steering-wheel spiders are among the products Alcoa says can be formed from a metal slug by a single press stroke. Integral spoke and vane roots made by the process will have the advantage of strength produced by the "forging" effect of the extrusion as well as the absence of a joint.



New flexibility for extruded product design is offered by the lateral impact technique. Compared are: 1. Lateral impact steering-wheel spider. 2. Reverse impact extrusion. 3. Forward impact extrusion. 4. Combination impact extrusion. Alcoa says that lateral impact extrusions have the toughness, density, and high-wrought strength of forged parts.

Plasma Thermocouple Produces Electricity from Atomic Energy

New Process Eliminates Costly Intermediate Steps

ANN ARBOR, MICH.—Ionized cesium gas is one element of a "thermocouple" that has produced direct current several hundred times higher than that of other thermocouple combinations known up to now. The complete power source, developed jointly by University of Michigan and Los Alamos Scientific Laboratory, is about the size of a frozen fruit juice can. A power rod of uranium carbide $\frac{1}{4}$ in. diam by $\frac{3}{4}$ in. long is suspended at the center of the cell and surrounded by cesium gas.

When the cell is lowered into

. . . Fluid Power news

REPORT NO. 11,704
Power and Control for New Lock Gates

From Oilgear Application-Engineering* Files

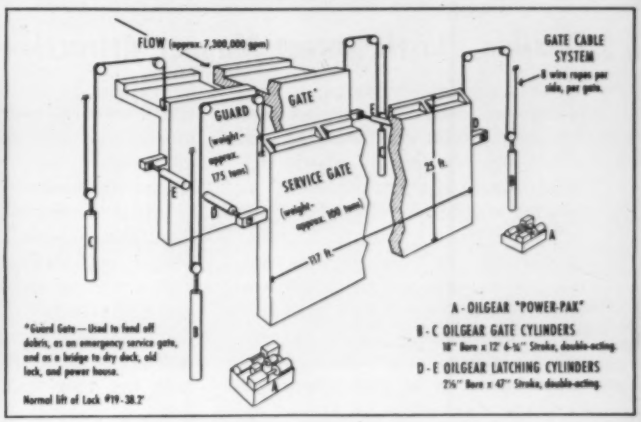
HOW OILGEAR AE* HELPS THE ARMY ENGINEERS SPEED MISSISSIPPI RIVER TRAFFIC

CUSTOMER: *Corps of Engineers, U. S. Army, North Central Division, Rock Island District*

DATA: Power and control system for lifting, lowering, and latching the 110-ft, single leaf, vertical lift, upper service and guard gates on new 1200-ft Mississippi River Lock #19 at Keokuk, Iowa.

REQUIREMENTS: 1. Foolproof, dependable, fast operation. 2. Simple, automatic, three-speed control from central station, interlocked electrically with lower miter gate, tainter valves, and lock water level. 3. System must incorporate: (a) Automatic latching, (b) Skew control to keep gates level during lifting and lowering, (c) Provision for emergency closing, (d) Automatic positioning for controlled supplemental fill of lock chamber over service gate top, (e) Additional lift-travel for cable and seal servicing, (f) "Fail-safe" operation in event of power failure.

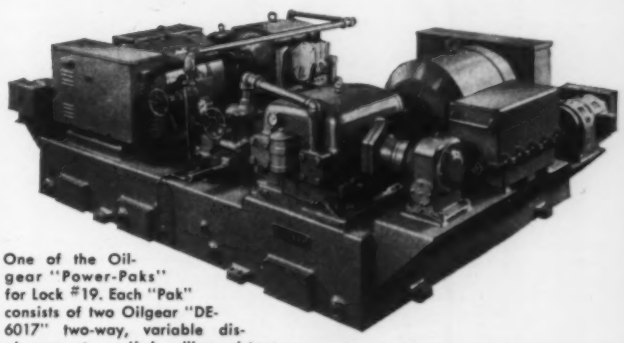
A typical "tow" entering new Lock #19 from upstream. In "locking-down" it will pass over the Oilgear-powered upper guard and service gates. Several "tows" can simultaneously "lock-thru" intact. New upper guard gate also serves as an access bridge to a dry dock and the old lock visible to the right of the new lock.


FLOW (approx. 7,300,000 gpm)
GATE CABLE SYSTEM
8 wire ropes per side, per gate.
GUARD (weight-approx. 175 tons)
GATE*
SERVICE GATE (weight-approx. 250 tons)
25 ft.
117 ft.
A - OILGEAR "POWER-PAK"
B - C OILGEAR GATE CYLINDERS
18" Bore x 12' 6-½" Stroke, double-acting.
D - E OILGEAR LATCHING CYLINDERS
7½" Bore x 47" Stroke, double-acting.
*Guard Gate — Used to fend off debris, as an emergency service gate, and as a bridge to dry dock, old lock, and power house.
Normal lift of Lock #19-38.2'

SOLUTION: An Oilgear *Application-Engineered* Fluid Power System which surpasses all originally specified requirements . . . as shown above in simple schematic form. This system consists of two Oilgear "Power-Paks" (A), four Oilgear custom, double-acting gate cylinders (B-C) — with integral solenoid pilot-operated brake valves, and four Oilgear custom, double-acting gate-latching cylinders (D-E). Entire upper gate control system is interlocked electrically with the lower miter gate and tainter valves for maximum operating safety. In event of power failure, solenoid pilot-operated brake valves, integral with cylinders, stop gate movement for "fail-safe" operation. Automatic skew control prevents "cocking" or binding of gates. A difference of 1½" in side height automatically reduces displacement of leading gate cylinder pump to allow lagging cylinder to catch up. Gate "down-cycle" power regeneration is an outstanding "Oilgear-plus" feature that furnishes exceptional electric power economy . . . utilizes the downward load on cylinder fluid to drive the Oilgear pumps as motors, reducing electrical power input. To speed lock filling, upper service gate automatically lowers to a supplementary fill position permitting controlled flow of water over gate top. Gate holds this position until water levels of upper pool and lock chamber are equalized, and automatically proceeds down at high speed. If water levels are equalized prior to start of cycle, gate does not stop at supplementary position. "Fill" time is only 10 minutes, drain time — 9¼ minutes. Entire "lock-thru" time for an 11-barge tow has been reduced from 7¼ hours to approximately 20 minutes with this new lock. In emergencies, upper gates can be raised or lowered against full river flow. Oilgear *Application-Engineered Controlled Motion Systems* are simplest to install, operate, and maintain . . . require less power to operate, reduce installed costs . . . are complete systems for specific applications — with one responsibility for the entire system.

* * *

Similar Oilgear systems are operating the St. Lawrence Seaway Eisenhower Locks, the Monongahela River Locks, the Bayou Boeuf Locks, the Dalles Locks, the McNary Lock — all projects of the Corps of Engineers . . . as well as operating miter gates, tainter valves, capstans . . . shipboard steering and flanking gear, winches, catapults, elevators, mobile oil drilling barges, and in all phases of industry. *Circle 407 on Page 19*



One of the Oilgear "Power-Paks" for Lock #19. Each "Pak" consists of two Oilgear "DE-6017" two-way, variable displacement, radial rolling piston pumps coupled to 50-hp electric brake-motors; two electric pilot gearmotors, reducers, limit switch boxes, and right angle worm-gear drives to pump controls. Also included are a manually operated Oilgear change-over valve, an Oilgear "HG" constant displacement axial piston pump for operating the latching cylinders — all on a custom oil reservoir base . . . completely wired and piped, ready for installation. Each Oilgear variable displacement pump is piped to one of the large gate cylinders. In the event that pump maintenance or inspection is required, the manual change-over valve permits either pump on the "Pak" to be idle while the other pump operates either the service or guard gate.

for the lowest cost per year . . . it's Oilgear!

For practical solutions to YOUR rotary or linear drive and control problems, call the factory-trained Oilgear Application-Engineer in your vicinity. Or write, stating your specific requirements, directly to . . .

THE OILGEAR COMPANY

Application-Engineered Controlled Motion Systems

1568 WEST PIERCE STREET • MILWAUKEE 4, WISCONSIN

the core of a reactor, the neutron flux heats the uranium carbide white hot while the flow of reactor coolant drops the temperature of the periphery. This meets the essential requirements of a thermocouple, producing electricity. The experimental unit had an open current voltage of 3.8 volts, and a short-circuit flow of 30 to 40 amps; it operated at design efficiency for 12 hours before being dismantled.

Professor Robert W. Pidd of the University of Michigan, who worked on the project with the Los Alamos Lab, says, "This could be the device that changes the reactor from a scientific instrument to a practical source of useful power."

Present reactors, to produce electricity in economically useful quantities, convert heat of the reactor into mechanical energy, and employ boilers, turbines, and gas condensers to run a dynamo. A research reactor, using the new development and needing none of this additional equipment, will be in operation in two years.

Flexible Plastic Latest Magnet Attraction

MARIETTA, OHIO — Koroseal vinyl plastic has entered the magnet field. Through special compounding and processing, the flexible plastic material reacts exactly like metal or ceramic magnets.

A result of four years development by B. F. Goodrich Co., the new magnet can be produced with poles at opposite ends, across the thickness, across the width, or even side-by-side. It can be extruded in any shape, and can be spot magnetized or shape magnetized for special applications. In addition, it is an electric insulating material able to retain its magnetic ability better than most conventional magnets, and is chemically inert.

Initial volume use is for refrigerator gasket material, where magnetic strip is used inside a synthetic gasket to form an airtight seal around the entire length of the refrigerator door. As the strength of the magnetic strip is more than enough to hold the door shut, the need for a latch is eliminated.

Flexibility and magnetic strength of the newly developed plastic magnet suggests use with bulletin boards, tool racks, and other storage or display devices.

Topics

No bills, just cash, might pour in every month if you power your house with rooftop solar cells. The trick is to turn excess sun-generated electricity back into the power lines for daytime industrial use and receive power-company credit. Ford Motor Co.'s Dr. Lawrence J. Giacoletto says that an average home owner with a 30 by 30-ft bank of solar cells could generate three times more energy than he uses. Pumped into the lines, the excess electricity would reverse the power-company's meter and subtract from kilowatt hours recorded when the sun wasn't shining. Dr. Giacoletto estimates a potential net return of about $200 per year to the homeowner.

• • •

Do-it-yourself dentistry isn't advised, but Public Health Service sees other interesting openings for portable dental equipment that's small enough to fit into two 45-lb cases. Including a full set of dental tools, drive motor, aspirator, and sprays, the outfit could be used to treat an estimated 5,500,000 persons who are too sick to visit a dentist's office. Ritter Co., Rochester, N. Y., manufacturer of the prototypes, will await results of the Federal study before making the kits in quantities.

• • •

Mr. Roberts could have skipped the iodine in his "Scotch" if he'd had Beckman Instruments' gas chromatograph aboard. Unlike other chromatographs—they only analyze things, says Beckman—the new Megachrom actually produces chemicals. Interesting examples are rare perfume oils, chemicals believed to cause cancer, and compounds that impart Scotch whiskey's smoky flavor. Slated for limited production next September, the new instrument will retail for $9250.

• • •

Don't bet against Einstein . . . scientists say that chances are 1000 to 1 that his theory of relativity is correct. However, just to make certain, physicists may set off a nuclear blast 100 million miles out in space. The explosion would emit a complete spectrum of radiation at a precisely known instant. If all wavelengths reach earth at exactly the same time, relativity checks out.

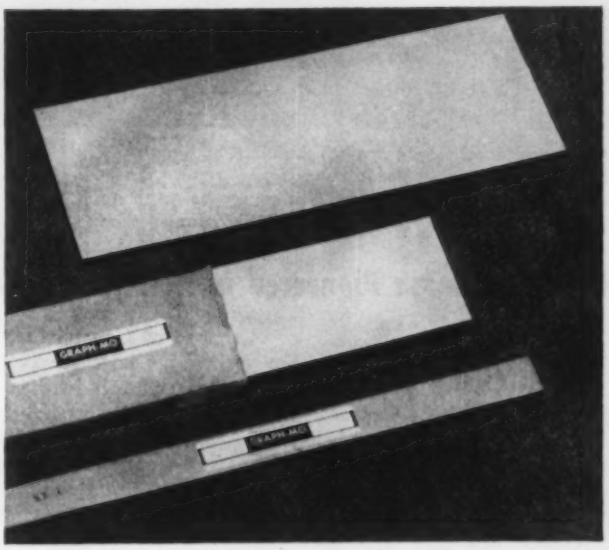
• • •

The well-dressed skin diver can now have his choice of a red, green, blue, or white suit made of closed-cell vinyl sponge. Colors make the diver easier to see and therefore safer under water, according to the manufacturer.

New economy for tool steel users . . .

FAMOUS GRAPH-MO® NOW AVAILABLE IN PRECISION GROUND FLATS

. . . from 41 distributors in 33 cities



Now you can get precision ground flats with all the advantages of the Timken Company's famous Graph-Mo® tool steel. They're available through the conveniently located distributors listed below. You get all these advantages: *Semifinished* . . . saving preliminary machining operations. *Graph-Mo outwears ordinary tool steels 3 to 1* because of the combination of free graphite particles and diamond hard carbides in its structure. *Machines 30% easier* than conventional tool steels. *Uniform response to heat treatment* eliminates distortion. *Specially wrapped* in protective envelopes carrying heat-treating information. *And there are 250 sizes* of flats to choose from.

Get your stock list from our distributors or by writing direct. There is only *one* Graph-Mo, and the Timken Company makes it. The Timken Roller Bearing Company, Canton 6, Ohio. Cable address: "TIMROSCO". *Makers of Tapered Roller Bearings, Fine Alloy Steels and Removable Rock Bits.*

DISTRIBUTORS OF TIMKEN GRAPHITIC TOOL STEELS

ALABAMA
Birmingham—O'Neal Steel, Inc.

CALIFORNIA
Los Angeles—Coulter Steel & Forge Co.
Los Angeles—Earle M. Jorgensen Co.
Oakland—Coulter Steel & Forge Co. (Emeryville)
Oakland—Earle M. Jorgensen Co.
San Francisco—A. Milne & Co., Inc.

GEORGIA
Atlanta—A. Milne & Co., Inc.
Atlanta—O'Neal Steel, Inc.

ILLINOIS
Melrose Park—A. Milne & Co., Inc.
Chicago—The Peninsular Steel Company

INDIANA
Indianapolis—The Peninsular Steel Co.

MASSACHUSETTS
Boston—A. Milne & Co., Inc.

MICHIGAN
Detroit—Alloy Steels, Inc.
Detroit—A. Milne & Co., Inc.
Detroit—The Peninsular Steel Company
Grand Rapids—The Peninsular Steel Co.

MISSISSIPPI
Jackson—O'Neal Steel, Inc.

MISSOURI
St. Louis—Ford Steel Company

NEW JERSEY
Kenilworth—A. Milne & Co., Inc.

NEW YORK
Buffalo—The Peninsular Steel Company (Tonawanda)
New York City—A. Milne & Co., Inc.

OHIO
Akron—The Peninsular Steel Company
Cleveland—A. Milne & Co., Inc.
Cleveland—The Peninsular Steel Co.
Dayton—A. Milne & Co., Inc.
Dayton—The Peninsular Steel Company
Dayton—Alloy Steels, Inc.
Toledo—The Peninsular Steel Company

OKLAHOMA
Tulsa—Earle M. Jorgensen Co.

OREGON
Portland—Pacific Machinery and Tool Steel Co.

PENNSYLVANIA
Philadelphia—A. Milne & Co., Inc.
Pittsburgh—A. Milne & Co., Inc.

TENNESSEE
Chattanooga—O'Neal Steel, Inc.

TEXAS
Dallas—Earle M. Jorgensen Co.
Houston—Earle M. Jorgensen Co.

UTAH
Salt Lake City—Coulter Steel & Forge Co.

WASHINGTON
Seattle—Coulter Steel & Forge Co.

CANADA
London, Ont.—Vanadium-Alloys Steel Canada Ltd.
Montreal, Que.—Vanadium-Alloys Steel Canada Ltd.
Toronto, Ont.—Vanadium-Alloys Steel Canada Ltd.

TIMKEN® *Fine Alloy* STEEL

SPECIALISTS IN FINE ALLOY STEELS GRAPHITIC TOOL STEELS AND SEAMLESS STEEL TUBING

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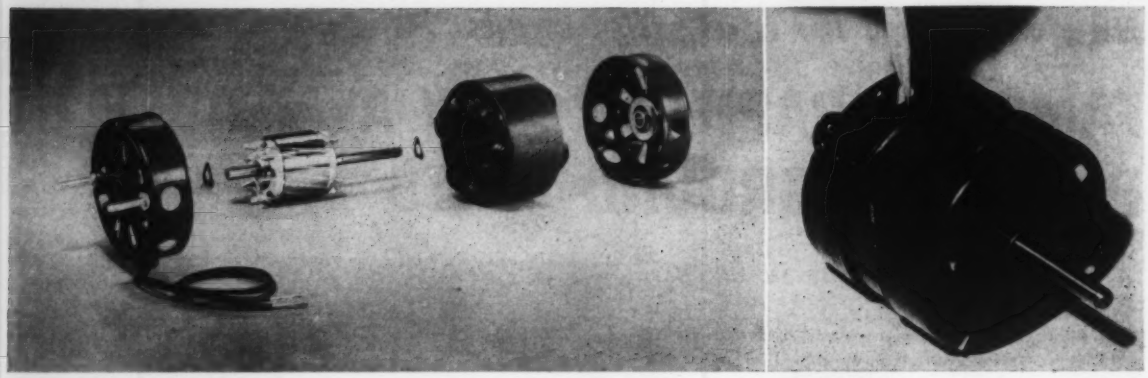


A special epoxy resin fastens bearing housings to end bells, left, and end bells to stator frame, right. The "unitized" motor, so named because it cannot be taken apart, will be available first in 4-pole KSM 59-frame shaded-pole and permanent-split capacitor ratings up through 1/15 hp. It will also be available soon in 2-pole shaded-pole ratings through 20 milli-hp and in universal series motors of various ratings.

Unitized Design Pioneered in New Motor Line

"Glued On" End Bells Assure Precision Air Gaps

SCHENECTADY, N. Y.—Expensive machining operations on end bells and stator frames of small electric motors are practically eliminated by a new unitized assembly technique. Close-tolerance air gaps and precision bearing alignment are obtained by "gluing" press-formed sheet-metal end bells to the motor stator.

In the new motor design developed by General Electric Co., bearing housings are first mounted on the end bells with a high-strength epoxy resin. After rotor-stator alignment is established by fixtures, end bells are slipped over the stator frame. Clearances between end bells and stator are filled with resin.

Epoxy resin is also used as winding-slot insulation. Unaffected by humidity, it gives a four-to-one improvement in dielectric strength, and a ten-to-one improvement in life over paper-slot insulation.

Performance benefits provided by the closely controlled air gap include reduced noise level, better starting characteristics, and higher efficiency, according to GE engineers. Improved magnetic circuitry yields higher efficiency and lower motor operating temperatures.

The unitized motors, so named because they cannot be taken apart after the resin sets, form a new supplemental small motor line.

See Full Representation at Design Show

On Hand: 4000 Specialists To Answer Visitors Queries

NEW YORK—Virtually every major company in the country will be represented among visitors at the Design Engineering Show when it opens on May 25 for a four-day run at Philadelphia's Convention Hall. Advance registrations and inquiries indicate that 20,000 of the nation's design engineers and product development executives will be on hand to inspect the exhibits of more than 400 companies, according to Clapp and Poliak Inc., exposition management firm.

Brand new in 1956, the Design Show has experienced an unprecedented rate of growth and will be one of the largest annual industrial expositions held in the U. S. in 1959. Products and displays will exceed $10 million in value, with more than 12,000 separate products on display.

Some 4000 technical specialists will be on hand to answer visitors' questions. Visitors will represent companies whose products range from household appliances to earth satellites and atomic reactors. Exhibits will include mechanical, electrical, electronic, hydraulic, and pneumatic components; power-transmission equipment; materials; fasteners and adhesives; finishes and coatings.

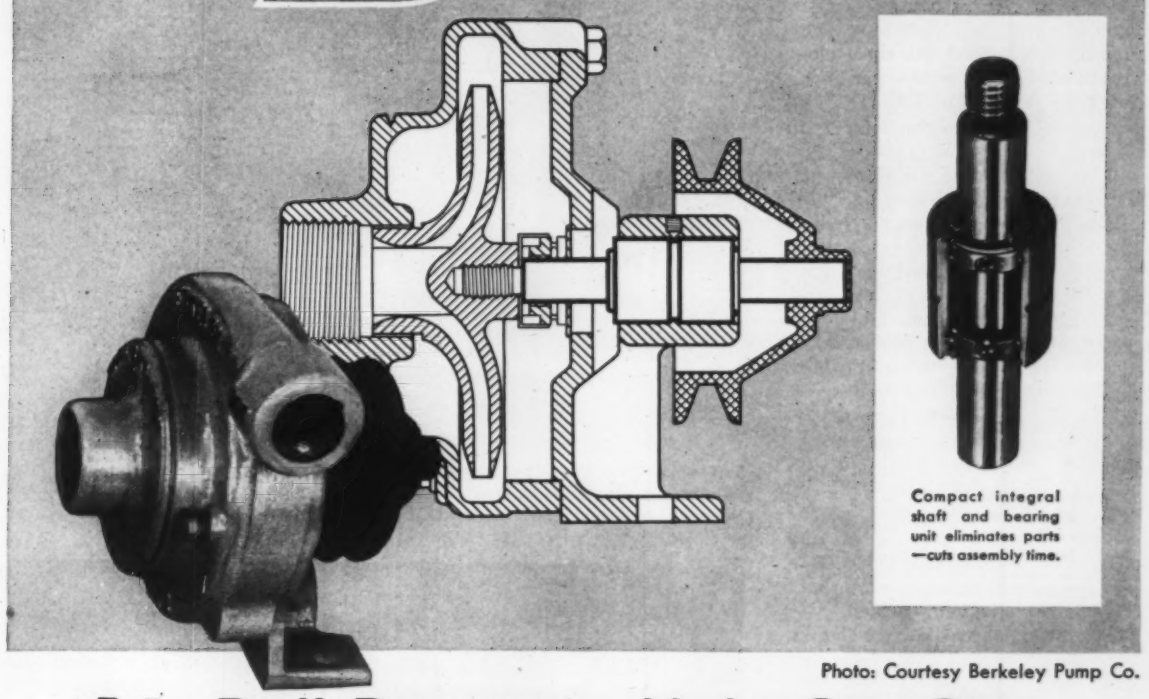
The four-day Design-Engineering Conference, conducted by the Machine Design Div. of ASME, will be held concurrently with the show. The first day's session will be devoted to the education of engineers. A paper delivered by Hellmuth Walter, director of research, Worthington Corp., Harrison, N. J., on "Engineering Design in Germany," will describe the technical education of German engineers, the role of the engineering executive in German industry, and the relationship of engineering to other phases of industry.

Another session, on the last day, will deal with efficient organization of a design department from the viewpoint of both the company—for efficient operation, and the engineer—for proper use of his talents.

On the second and third days of the conference, there will be three concurrent sessions devoted to choice of materials in design, mechanical aspects of design, and power and control.

The next issue of MACHINE DESIGN will feature a comprehensive 32-page Show Guide, including a roundup of new products on display, a list of all exhibitors, floor plan of Convention Hall showing location of each booth, and a complete program of the conference.

CASE HISTORIES



Compact integral shaft and bearing unit eliminates parts —cuts assembly time.

Photo: Courtesy Berkeley Pump Co.

N/D Ball Bearings Help Cut Size... Lower Costs $2.50 Per Pump!

CUSTOMER PROBLEM:

Redesign utility water pump for Air Conditioner market. Conversion must achieve smaller size without reducing pump capacity. At the same time, customer must lower over-all production costs.

SOLUTION:

N/D Sales Engineer suggested the versatile New Departure fan and pumpshaft ball bearing. This compact precision bearing permitted use of over-the-housing pulleys with belt load located over the raceway. Its integral shaft, which is the inner race, simplified design and helped reduce housing size without changing pump capacity. In addition, the sealed and lubricated-for-life bearing replaced two sealed bearings, separate shaft and snap rings . . . cutting part and assembly-time costs $2.50 per pump.

Perhaps one of New Departure's wide selection of *production* ball bearings will help give *your* product the sales appeal and cost savings you're looking for. For more information, call the New Departure Sales Engineer in your area or write Dept. Q-4.

Replacement ball bearings available through United Motors System and its Independent Bearing Distributors

NEW DEPARTURE

DIVISION OF GENERAL MOTORS, BRISTOL, CONN.

NOTHING ROLLS LIKE A BALL

Circle 409 on Page 19

Rivet-Like Welds "Button" Metal Sheets Together

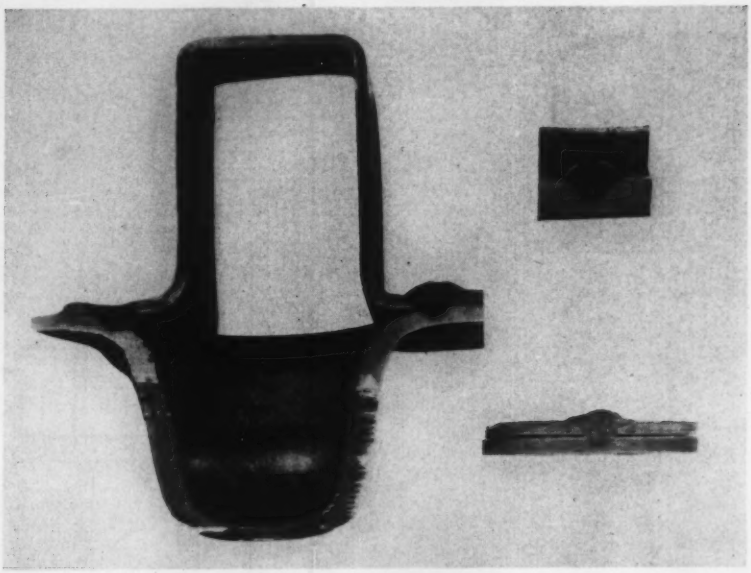
Lightweight Gun Brings Shielded Arc to Job

MILWAUKEE—Fused buttons that resemble rivets in appearance and function are burned into sheet metal by a "button weld" gun produced by A. O. Smith Corp. As a means of joining sheet steel economically and quickly, the buttons will compete with conventional resistance welding and riveting.

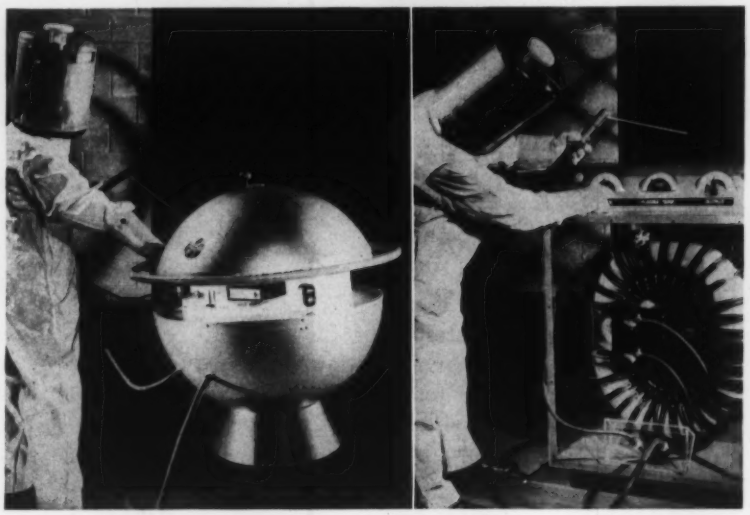
The lightweight, water-cooled gun is easy to hold and move along the job. A CO_2-shielded arc burns a hole into the upper sheet and part of the lower sheet, and fused metal, augmented by the consumable-electrode wire, forms the button. Arc time and wire-feed speed are closely controlled to form uniform, accurate buttons, and control depth of burn through.

Sheets from 0.035 to 0.181 in. thick are effectively joined by the process. Heavier gage sheet and plate can be buttoned in place of manual tackwelding. Stock over 3/16 in. thick can be plug-welded.

Operators wear no face masks. Tinted safety glasses give adequate protection from the reflected glare that spills from four gas ports in the carbon dioxide hood.



Buttons of filler metal penetrate into second layer of a two-layer buildup. Time of arc and rate of wire feed control size of button and depth of burn-through. These button welds can be made through dirt and grease.



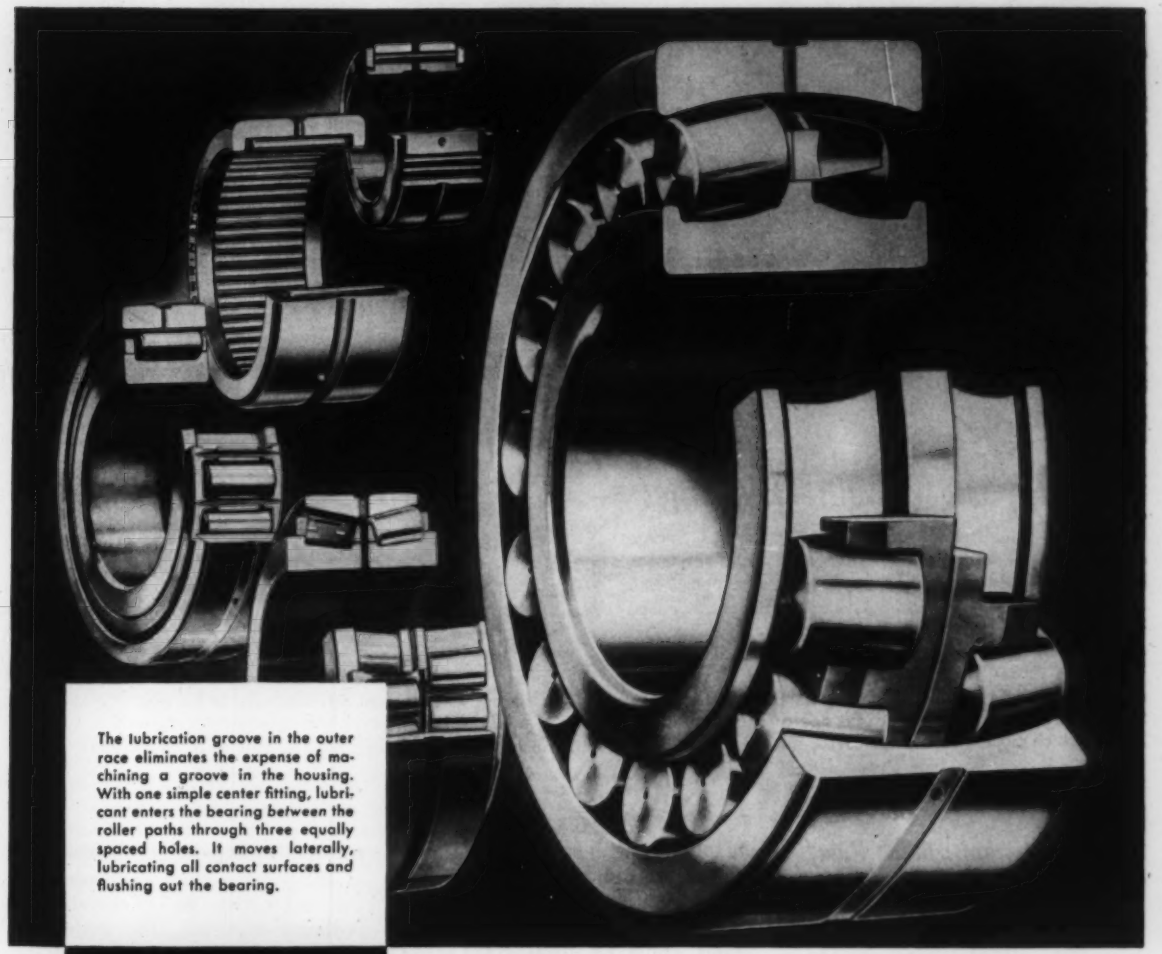
Possible future developments in welding are displayed by A. O. Smith Corp. at the American Welding Society Exposition in Chicago. Left, antigravity welding machine can be pulled effortlessly to the job. Source of power might be a self-contained thermoelectric generator. Right, self-contained welding power supply would generate 20,000 kw by thermonuclear fusion using deuterium as a fuel.

Radar Detection Tube Stores Only Moving-Target Data

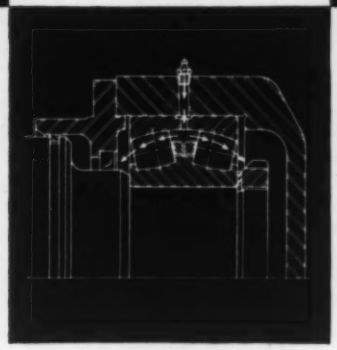
WASHINGTON — Developed specifically for radar detection systems, a new electronic storage tube is quite versatile. It can eliminate ground clutter (buildings, mountains, etc.) in radar by passing only the moving target signal. It can also amplify faint or distant signals and read and store information.

Strengthening of faint signals is accomplished by an integrating process which makes them visible above background noise. Information storage is possible in binary digital form at very high speed. High resolution permits a large storage capacity.

The tube's design is unique. According to its developers, International Telephone and Telegraph Corp., Nutley, N. J., the storage element consists of a curved metal ceramic-coated bowl, the barrier grid being formed into the bowl and fused to the storage surface. Little shading signal over the storage surface occurs for high-resolution storage. The fused structures result in a high ruggedness permitting wide application in infrared detection systems, telephone switching systems, and electronic computers.



The lubrication groove in the outer race eliminates the expense of machining a groove in the housing. With one simple center fitting, lubricant enters the bearing *between* the roller paths through three equally spaced holes. It moves laterally, lubricating all contact surfaces and flushing out the bearing.



See Our Exhibit
International Petroleum Exposition
Tulsa • May 14-23

A time-proved lubricating method now available on Torrington Spherical Roller Bearings

The circumferential groove in the outer race has met the test of experience in many Torrington Bearings, including Heavy Duty Needle Bearings, Aircraft Type Needle Bearings, Tapered and Radial Roller Bearings. Now the circumferential lubrication groove is available in Torrington Spherical Roller Bearings.

This design feature makes it possible to introduce lubricant *between* the roller paths without the expense of machining a groove in the housing. This groove is proportioned to provide generous lubricant flow capacity. Lubricant moves through the roller paths, flushing used lubricant and contaminants away from bearing contact surfaces.

Torrington Spherical Roller Bearings in many sizes may be ordered with this groove as desired at no additional cost. For further information, see your Torrington representative or write: **The Torrington Company, South Bend 21, Ind.—and Torrington, Conn.**

TORRINGTON BEARINGS

District Offices and Distributors in Principal Cities of United States and Canada

SPHERICAL ROLLER • TAPERED ROLLER • CYLINDRICAL ROLLER • NEEDLE • BALL • NEEDLE ROLLERS • THRUST

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U. S. Will Import Antitank Missiles

Small, wire-guided, solid-fuel missiles, capable of knocking out any tank known to exist in present day armies, will be imported from France by the Army. The powerful weapons, designated SS-10 and SS-11, can be hand carried by a single soldier and launched from the ground or from almost any vehicle, helicopter, or airplane. As the missile speeds toward its target, it unreels a fine wire and is guided electronically by one man at the controls of a small console. SS-10, shown above, will become operational immediately. SS-11, which closely resembles SS-10, but has greater speed and about twice the range, will be procured in evaluation quantities. Developed by Nord Aviation, Paris, the missiles are the first ever imported by the U. S. They will probably form the backbone of U. S. antitank forces, unless another weapon, now on paper at Ford Motor Co.'s Aeronutronic Systems Inc., proves successful. While few details of the Aeronutronic missile have been disclosed, it is described as a radical advancement in the art. The weapon is said to have an optical guidance system and will be designed to fire from a moving tank at a moving tank.

Soviet Predictions: Moon Rain, Photon Rocket for Space

WASHINGTON—Recent Russian predictions lend credence to some favorite American science-fiction plots. In "The Cosmic Future of Mankind," F. Zigel', Candidate of Pedagogical Sciences, discusses the colonization of the Moon and predicts the photon engine will open man's path to the stars.

After detailing initial procedures for colonization and early stages of man's Moon life, Zigel' predicts a sophisticated moon society with atomic powerplants able to synthesize an earth-like atmosphere from the lunar crust. This warm blanket of atmosphere would be equipped with artificial clouds and, hence, rain. Because of low moon gravity, the atmosphere would be continuously generated to make up for losses. Projected timetable includes a maximum of one generation for initial conquest, and 100 years for the refined colony.

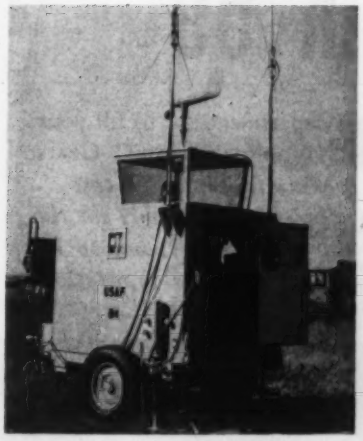
Continuing, Zigel' further prophesies the photon rocket engine will carry man to outer space. The engine will obtain power by combining protons with antiprotons, neutrons with antineutrons, etc., thereby converting matter to photon energy. The hard-radiation photon beams would be directed by parabolic mirrors to give the desired rocket-like impulse. Problems arise in designing a storage chamber for the antimatter. In a chamber of ordinary materials, the antimatter would react with the matter of the chamber walls.

Engineering Degrees—Up Again in '58

Engineering colleges graduated 13.1 per cent more engineers in 1958 than in the preceding academic year. Figures released by Engineers Joint Council and Engineering Manpower Commission also show a 9.5 per cent gain in the number of science graduates. In all fields, 1958 was the better year by 7.5 per cent. There is no significant change in the number of master's degrees earned in engineering, but an improvement is noted in the number of doctorates: An increase of 51 for 1958. This compares to a decrease in the number of doctorates between the two preceding years—in '56, 610 engineering doctorates were awarded and in '57, the number dropped to 596.

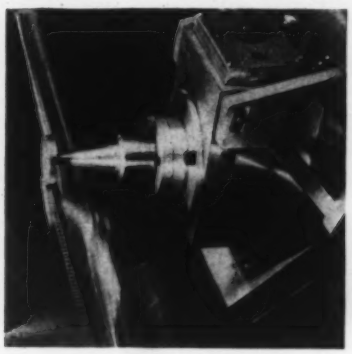
Science Degrees—1956-57 and 1957-58

	—Bachelor—		—Master—		—Doctor—	
	1956-57	1957-58	1956-57	1957-58	1956-57	1957-58
Engineering	31,211	35,332	5233	5788	596	
Agriculture	7943	8312	1549	1480	353	353
Biology	13,868	14,408	1801	1852	1103	1125
Mathematics	5546	6924	965	1234	249	247
Physical Sciences	12,934	14,352	2704	3034	1674	1655
Psychology	6191	6930	1095	836	550	572
Totals	77,693	86,258	13,347	14,244	4525	4599
All Others	262,654	279,490	48,608	51,390	4231	4343



Have Tower, Will Travel

A new mobile control tower can be airlifted by helicopter or pulled by truck. After reaching its destination, it is operational within 30 minutes. Designed and manufactured by Craig Systems Inc., Lawrence, Mass., it contains all the electronic equipment necessary for control and guidance of aircraft at an airstrip. Major components include receivers, transmitters, telephone control panels, wind indicator, altimeter, and signal light. The observation dome lowers into the van during transit. Interior dimensions with observation dome in operating position are 70 in. long by 58 in. wide by 73 in. high.



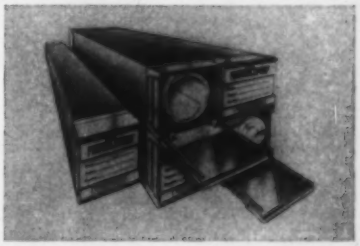
Sound Splices Foil

A major packaging advance announced by Aluminum Co. of America, Pittsburgh, is an ultrasonic welding (splicing) machine used for joining rolls of aluminum foil. Developed jointly by Alcoa and Aeroprojects Inc., West Chester, Pa., the ultrasonic splice is accomplished by a roller vibrating 50,000 times per second. The new technique is expected to aid users of long foil strands who previously had to stop equipment to remove wide and heavy splices employing adhesives.

DRAFTING TRENDS

Whether you are filing a few hundred or hundreds of thousands of drawings, you will find easily expanded and easily altered Pack Inter-Lock units give you both the accessibility and the flexibility you need for efficient filing.

Ingenious new way to solve drawing storage problem



Finding a place to store drawings is becoming a tougher and tougher job every year.

One hope toward finding unused space for storage seems to lie in using what is now thought of as "dead space"...the area between the top of present filing systems and the ceiling...between files...under tables and many other nooks and crannies where it would not be practical to put a full sized filing unit.

These are some of the reasons why much interest is currently being shown in the newly introduced Pack Inter-Lock filing system.

The basic unit of a Pack Inter-Lock file is a cylindrical air-tight, dust tight, light-tight compartment in which one drawing, or many drawings rolled together, or four separate rolls of drawings may be stored. The door of each unit contains a card serving as an index for the drawings inside. Color coded index cards, specially made for the Pack File, can be slipped into the door slot to show the current status of a drawing.

These compartments dovetail into each other and are locked into position by metal key pins that simply drop into position, thus making stacks of files into solid units. The stacks are easily altered, permitting great flexibility in arrangements of file space.

Although especially appropriate for storage of inactive or obsolete drawings (with a complete project of up to 30 tracings group-rolled into one compartment), Pack Files are also convenient for current work. The funnel-shaped openings provide fingertip removal or insertion of drawings without damaging them. Excellent protection is assured in the crush-proof, fire-resistant compartments.

For more information on Pack Inter-Lock filing systems, write today to Frederick Post Company, 3652 N. Avondale Avenue, Chicago 18, Illinois.

POST

SENSITIZED PAPERS & CLOTHS • TRACING & DRAWING MEDIUMS • DRAWING INSTRUMENTS & SLIDE RULES
ENGINEERING EQUIPMENT & DRAFTING SUPPLIES • FIELD EQUIPMENT & DRAFTING FURNITURE

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THIS MUCH MORE in '59

Expansion was not the order of the day during the past year, but it was in this period that the growing sales of "Double Diamonds" required the addition of 60% more manufacturing space. Hence, we now enter the more promising future with better and more facilities to serve as your "gear department" or to fill your gear orders with "Double Diamond" Gears that are built *to produce low installed cost... to serve economically and dependably on the job for which you buy them... and to do credit to your product and your reputation.*

May we send you this catalog of the gear types in which we specialize: helical gears, flywheel starter gears, straight bevel gears, straight spur gears, angular bevel gears, hypoid bevel gears, gear assemblies, zerol* bevel gears, spiral bevel gears, and spline shafts?

*Reg. U. S. Pat. Off.

EATON

AUTOMOTIVE GEAR DIVISION
MANUFACTURING COMPANY
RICHMOND, INDIANA

GEARS FOR AUTOMOTIVE, FARM EQUIPMENT AND GENERAL INDUSTRIAL APPLICATIONS
GEAR-MAKERS TO LEADING MANUFACTURERS

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Reader Information Service

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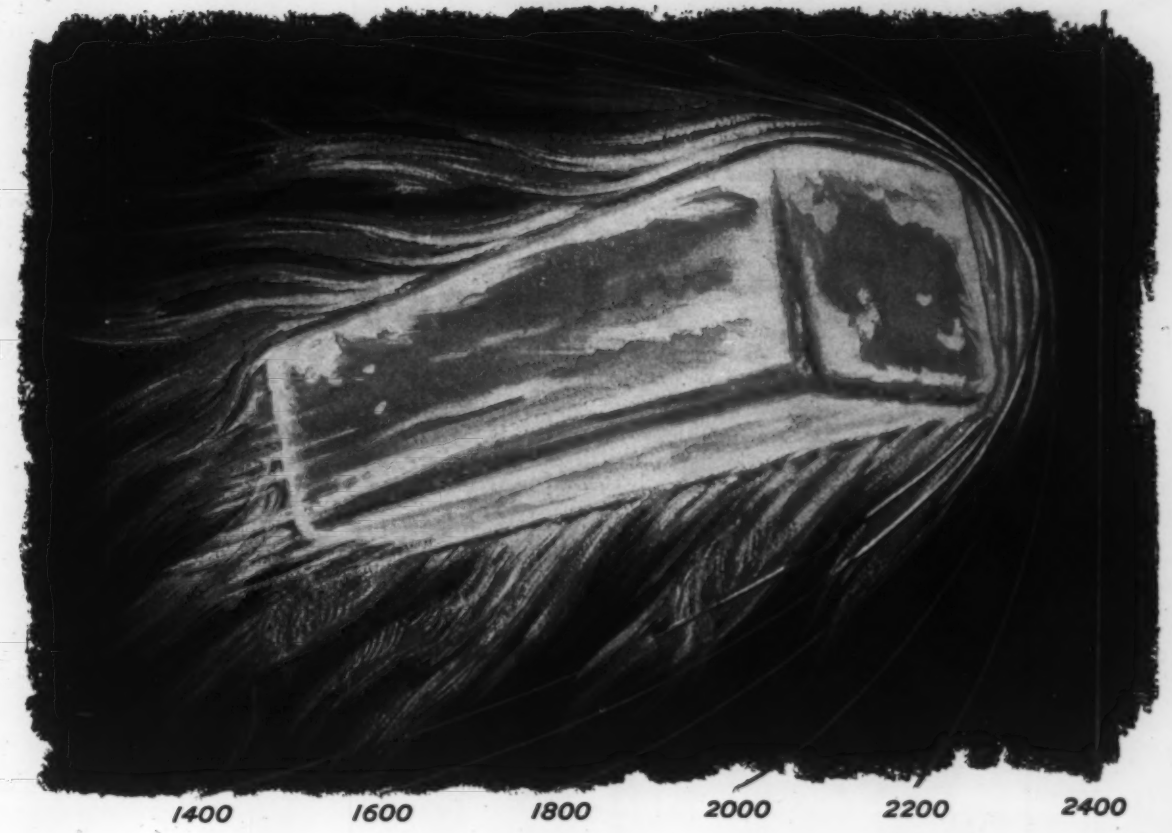

Bending the Heat Barrier

Specialized mill equipment is available at HAYNES STELLITE for rolling high-temperature alloys into a variety of shapes and sizes. Bar (above) is being produced on a 24-inch mill.

High strength plus resistance to oxidation, creep, thermal shock, and fatigue—are some of the properties that have helped to push the heat barrier back over the past 15 years. These are the properties found in HAYNES high-temperature alloys. Properties that make these alloys very useful in the 1000 to 2000+ deg. F. range.

Typical uses? The really hot spots in jet aircraft, ramjets, and missiles are some. Furnace components, heat-treating equipment, kiln liners are others. In fact, any part where long service life under severe high-temperature conditions is essential.

There are 12 HAYNES high-temperature alloys—available immediately in convenient forms that can be readily fabricated. For information on properties and prices, write for descriptive literature.

HAYNES
ALLOYS

HAYNES STELLITE COMPANY
Division of Union Carbide Corporation
Kokomo, Indiana

UNION CARBIDE

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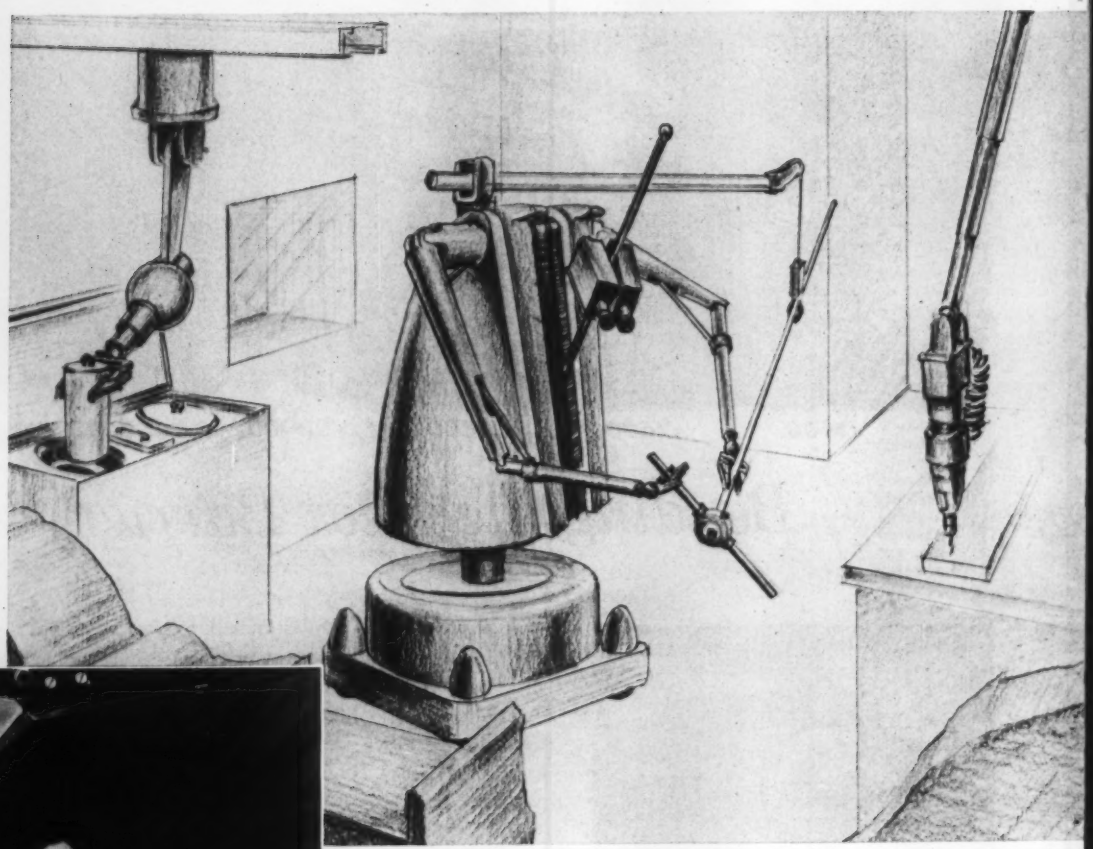
Circle 413 on Page 19

A new race of mechanical men is being born.
To meet the dangers of operation in radioactive areas,
designers are creating robots
which duplicate human movement and senses.
Although today they're destined for a life in a sealed cell,
these robots may be the ancestors
of a new breed of outer-space "men."

Almost-Human



GE Handyman "hears," "feels" and, to a very limited degree, "thinks" for itself. It has proved capable of lifting more than its rated capacity of 85 lb, yet can make very precise adjustments to do delicate jobs. It can pick petals off a daisy, says GE.

A heavy-duty manipulator capable of grasping forces up to 150 lb, General Mills' model 300 has a touch so precisely controlled that it can handle fragile glassware. It is not strictly a slave manipulator, since the console controls are guided by motions generally different from those the mechanical hand is expected to produce.

Engineering

HOW CLOSELY CAN a mechanical man duplicate the functions of a human?

Among the most arresting examples are the science-fiction type robots dreamed up by workers with nuclear energy to keep their own hands and bodies from fatal contact with the products of their trade.

Mechanical manipulators that cleverly duplicate the motion of the human hand have been around for some time; so have electric and hydraulic manipulators for multiplying the operating force of the human hand.

But in new completely sealed alpha-gamma facilities like that being constructed at Argonne National Laboratory, the problem is more difficult. For effective sealing, the mechanical man must be completely isolated from his human operator.

So the designer faces the job of refining the earlier inventions and combining them into something resembling a seeing, feeling, hearing, thinking and working being.

Workings of a Metal Hand

Most manipulators have two fingers to a hand. Mechanically, these are closed by some variation of a lazy tongs mechanism, with the wrist-pin fixed. Sometimes a spring-return opens the fingers. Cables, hydraulic plungers, rods, and wedges have all been used to actuate the mechanism.

To hold the relatively large and clumsy fingers parallel during opening and closing, four-bar linkages have been used for each finger. This design was very successful and widely used.

General Electric has developed a new electronically controlled hydraulic hand that has three joints in each finger, and small spring-actuated pistons on the finger pads for distributed grip on an uneven surface. Motions of this hand closely copy those of the human hand.

Argonne Lab has classified the operation of the human hand into seven fundamental motions: Translation in each of three directions, rotation about each of three axes, and grasping. To correspond with these motions, Argonne's mechanical manipulators, and its later electronic manipulators, like the arms of its robot, have seven basic joint movements.

The General Mills 300 manipulator has fewer joints, but a telescoping and overhead-track mounting give it the same range.

By adding the action of its complicated hand, GE lists ten basic motions for its Handyman, but its analysis is generally comparable to that of Argonne Lab.

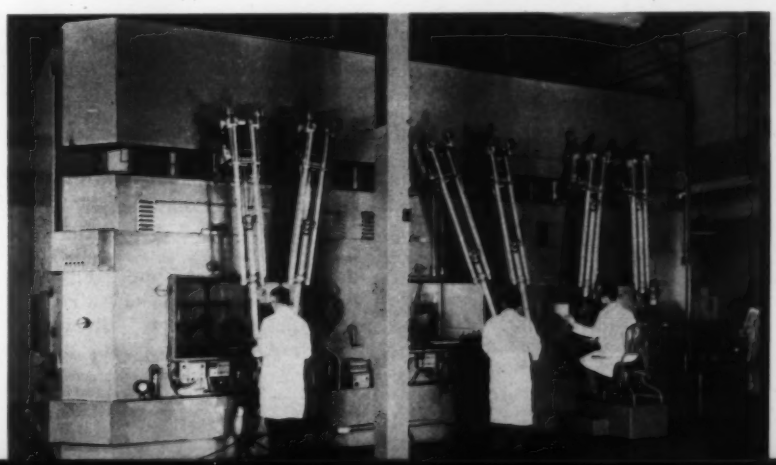
In the Argonne model, wrist motion and certain other motions are transmitted by small aluminum gears actuated by cables over pulleys. Hydraulic pistons, servo motors and four-bar linkages are also commonly used in Argonne and other models to transmit one or more of these motions.

Robot Muscles

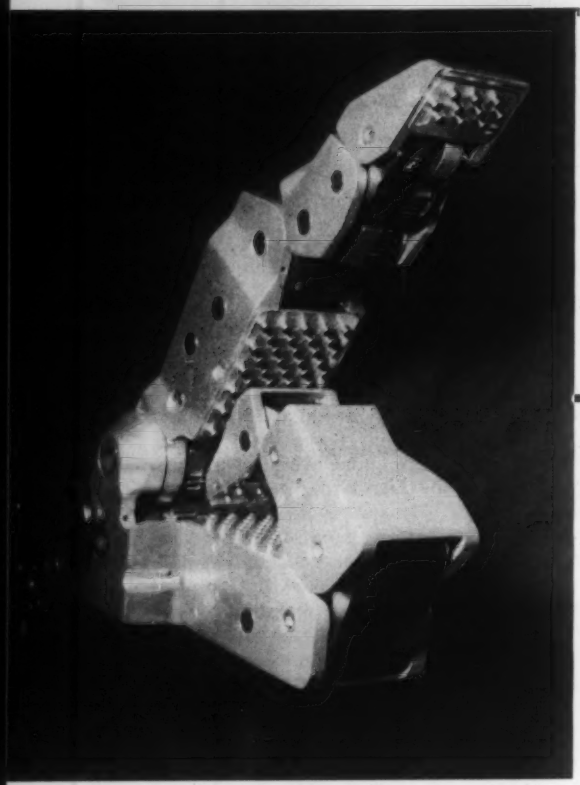
How strong should our mechanical man be? The first guess is that he should have the same strength as the human he replaces. But, if he were a little stronger, he could do some jobs more easily.

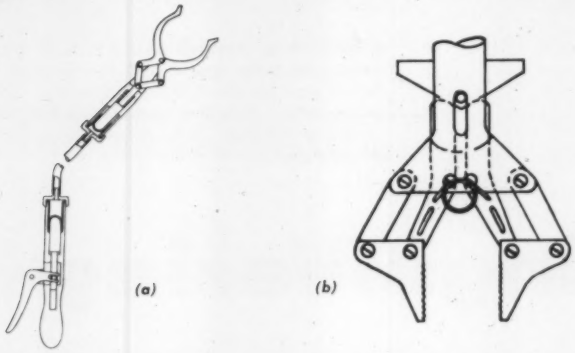
In spite of the designer's skill, however, he is more clumsy than a man. He doesn't use his body as a column or a lever nearly as well as a man.

Early mechanical manipulators



Mechanical manipulators link the operator to his work in this three-cell cave at Argonne's gamma facility. The mechanical coupling through the wall is hard to seal, so this type of manipulator is undesirable in the sealed cave used for new alpha-gamma facilities.





Mechanical hand evolved from the simple grasping claw, **a.** Fingers are held parallel by a four-bar linkage operated by a wedge, **b,** cable, **c,** or rack, **d.**

Complex hand of General Electric's electronically controlled hydraulic Handyman has four finger motions: Finger bend, finger curl, thumb bend, and thumb curl. Multiple spring-loaded buttons give the hand a firm grip on odd-shaped objects.

usually had a force ratio of 1:1. General Mills 300 manipulator has been built to exert a firm grip—up to 150 lb. The operator's force is multiplied by hydraulics and electric motors.

Argonne Laboratory is working with the idea of a 3:1 slave-to-master force ratio that can be changed to 1:1 at the flick of a switch. General Electric can choose 10:1, 5:1, 3:1, 1:1, or a setting that produces high force with no operator "feel." But it takes a second man at a switchboard to control these ratios.

Power for Argonne's slave comes from seven servo motors per arm. Each motor produces one of the seven basic motions in Argonne's list. Cables over pulleys transmit the power to the joint where gears or linkages apply it to the job.

General Electric uses a combination of servos and hydraulics to apply power to its man. He is designed to lift a load of 85 lb, using his weakest members. Reports are that he can do considerably better than that.

The Nerve Network

What initiates the robot's movements? General Mills has a console with controls that guide the motions of its manipulator. It is not a "slave" manipulator; it does not literally reproduce the motions of the operator's hands. The operator must consciously interpret what he wants from the manipulator into an appropriate motion with his own hands.

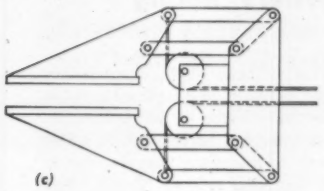
Designers want the type of slave motion that demands the least possible reasoning on the part of the operator. His mind should be free to think about the problems of the job rather than the intricacies of his robot. So designers work on what Argonne calls a slave robot with a low IQ that would imitate the motions of a master unit.

In GE's and Argonne's units, position-force servos pick up the motion of the master unit and relay a command to the slave. To feel what the slave "feels," the master units are equipped with a power-reflecting servo system. In the Argonne model, ANL-3, motors opposed to the command motors are actuated by resistance to the robot hands, and apply a similar resistance to the master unit. GE's system is similar, except that a complex electro-hydraulic system is used.

An entirely different approach to the remote control problem has been developed by Babcock and Wilcox, Lynchburg, Va. A manipulator mounted on a truck is controlled entirely by use of ultrasonics. This method gets rid of the rat tail of electric cable sweeping behind other models.

Stiff Joints and Heavy Limbs

Every joint fights back. The arms and hands are heavy. Inertia and overhang fight the operator. Precision in manufacture, concentration on lightweight parts, use of low-friction motors, and counterweights on mechanically extending and contracting frames are Ar-



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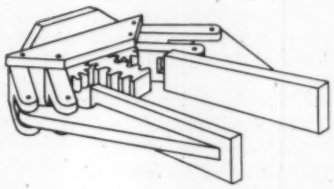

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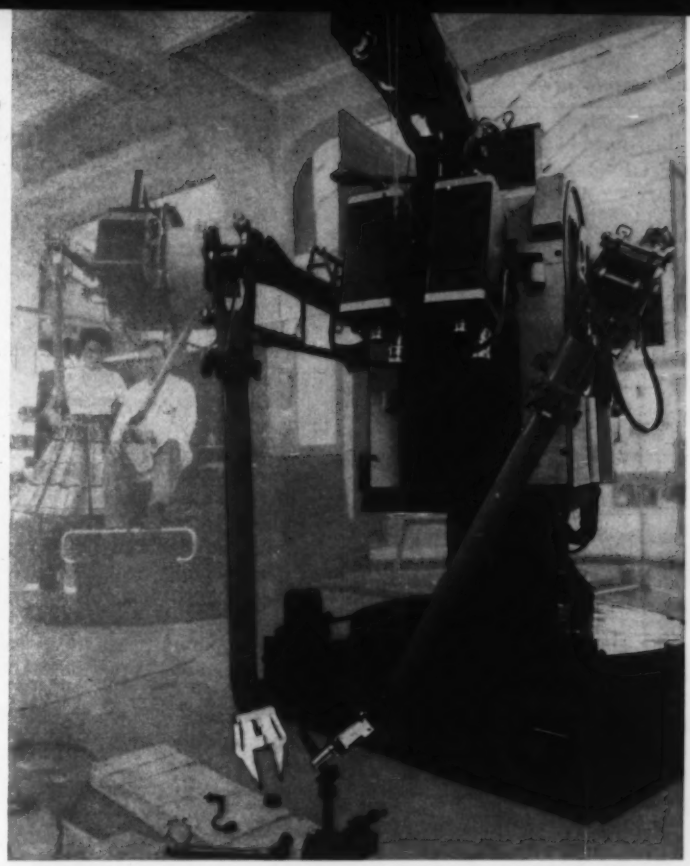
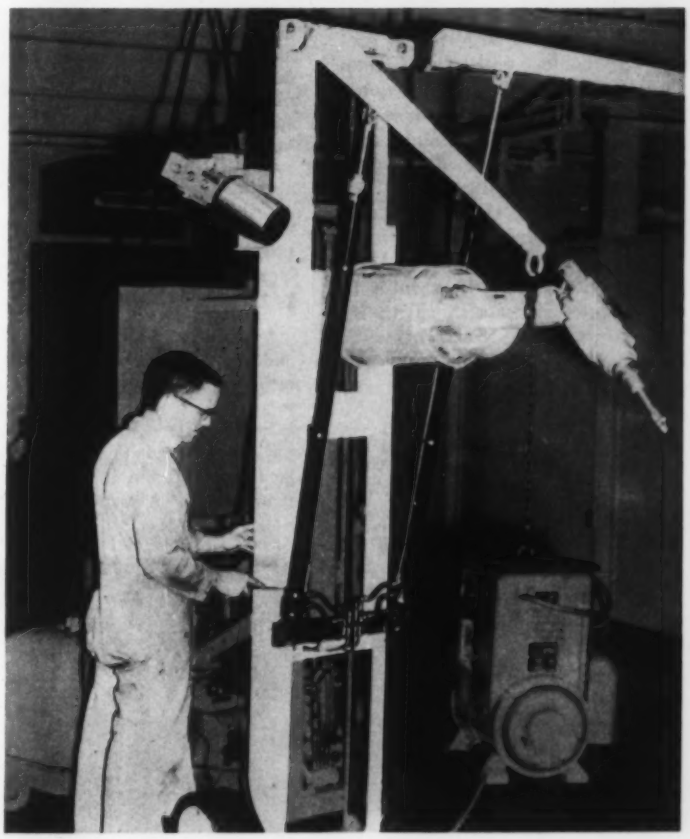


Experimental electronic robot developed by Argonne National Laboratory is the third model (ANL-3) in the laboratory's evolution of an electronically controlled "slave" robot. It is the prototype of those to be used in Argonne's alpha-gamma facility now being built.



Controlled ultrasonically, this unit consists of a truck, two cranes, and manipulator. The Babcock and Wilcox robot needs no trailing cord. TV unit at upper left gives human operator a view of the work being done.

gonne's answers to these problems. GE has another. The robot's analog computer brain "reads" every command of the master unit, automatically figures what the overhang and inertia will be, and orders a compensating adjustment that allows the operator to feel only the resistance of his work.

Eyes and Ears

For practical use, the mechanical man needs some refinements. Eyes and ears have to be added.

On the ANL-3, the 3D television eyes are extremely mobile on a long, thin neck. The neck moves up and down for a long range of vision, and lens turrets on each camera

add adjustability. A microphone on the GE Handyman adds monaural hearing.

Increasing the Life Span

In sealed hot cells, a mechanical man will be inaccessible. He'll be exposed to shock, heat, wear, and radiation. He will not come out for repairs or reservicing for the rest of his useful life.

Robots and overhead manipulators will repair themselves and each other as long as economically feasible, and when they are worn out, they'll either go into a discard room for second-hand parts, or into a radiation-proof container for burial. So there is extra reason for building durable robots.

Wear, shock and unbalanced weight are important considerations in the highly stressed little gears of the wrist and arms, as well as in the bearings. However, finding radiation-proof materials is the biggest problem.

Insulation and lubrication, for instance, must be radiation-resistant; so must hydraulic fluids.

Plastics are nearly out of the picture. It would be desirable to coat running cables with low-friction plastic—except that radiation would soon ruin it. Bare steel cables bite into aluminum pulleys and cause galvanic action that deteriorates both cable and pulley. Now Argonne is using steel tape over crowned aluminum pulleys.

The robot's joints are designed for easy assembly or disassembly by robot hands. Pins with E-ring retainers fasten many of the links in ANL-3.

What Next?

Radiation dangers have created the first real demand for a mechanical man. But refined robots may find applications in other areas. Hughes Aircraft Co. suggest that its mechanical man may be first on the moon (MD, April 16, Page 12), and also speaks of ocean-bed farming. Robot satellites may make their own repairs. Robot policeman may man busy corners. Robot sandhogs may dig transoceanic tunnels. In fact where a man now does any dangerous job, a robot may replace him.—T. M. Leach.

Plastic Makers Burn Over Underwriters' Ruling

So U.L. Calls Another Meeting On Plastics in Appliances

New York—Early this year, Underwriters' Laboratories Inc. declared that as soon as their codes could be revised (probably by 1960), "Only self-extinguishing plastics, or better, will be allowed in any electrical appliance—refrigerators, TV sets, radios, room air conditioners, etc. To prove their point, they issued the now controversial Bulletin 484, setting up specifications for plastics used in room air conditioners.

This is the background of a top-level meeting, scheduled for April 30, between U.L. officials and representatives of the plastics and appliance industries. The general state of mind, as MD went to press, can best be described by the following statements made by various representatives as they prepared to attend the meeting:

Speaking for the plastics industry, C. R. Mahaney, vice president, St. Regis Paper Co., had this to say:

". . . the arbitrary moves Underwriters' Laboratories Inc. have made to practically eliminate the use of plastics in room air conditioners baffles we people in the plastics industry. Considering plastics' fine record in this application and in electrical appliances generally, it is our feeling this step and those contemplated have been hastily undertaken without taking all pertinent factors into account."

Dr. Russell B. Akin, technical sales laboratory, E. I. duPont de Nemours & Co., commented in part as follows:

". . . the Manufacturing Chemists Assoc. and the SPI were not consulted in the preparation of Bulletin 484, nor advised of it. . . . We heard of it when customers and manufacturers asked what material we might recommend to meet the new requirements upon reading of these rigorous tests proposed by the Laboratories, and noting the intent to apply them this year.

"What is Bulletin 484? It prescribes tests to exposed parts and finished parts to determine their degree of self-extinguishment after a Bunsen burner test. . . . The requirement is that three samples are to be tested and the average burning time shall not be more than 25 seconds after the removal of the flame. This is an exceedingly difficult requirement to meet with any of the material we now know."

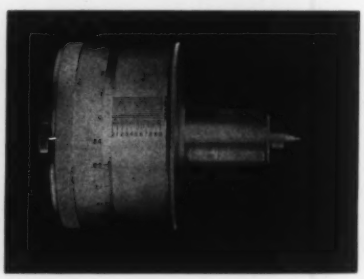
Speaking for the Manufacturing Chemists' Association, W. C. Goggin, manager Plastics dept. Dow Chemical Co., said:

"The Plastics Committee of MCA thoroughly discussed the Underwriters' Laboratories' ruling which, in effect, condemns the use of plastics in appliances.

"The discussion concluded that the facts available, even the limited facts supplied by U.L., showed personal and public hazards, including smoke damage and electrocutions, to be less through the use of well designed plastics than with older type materials. It fully supports the stand that plastic materials used in appliances neither have in the past nor will in the future represent a significant personal or public hazard."

In reply to the furor caused by Bulletin 484, U.L. officials emphasized that the Bulletin is simply a proposed requirement applicable only to room air conditioners, and subject to refinement. However, they also said that while suggestions will be received from industry representatives at the April 30 meeting, U.L. must reserve the right to accept or reject the recommendations offered. The officials base their stand on the grounds that combustible plastics are replacing noncombustible materials at an "alarming rate."

U.L. officials concluded that consideration will also be given to setting up a procedure to improve relations between Underwriters' Laboratories Inc. and the plastics industry.



Ultra Mike Measures Millionths

Ten millionths of an inch are represented by each vernier mark around the 4-in. diam barrel of this micrometer. The Sheffield Corp., Dayton, Ohio produced the micrometer to meet the exacting needs of modern technology. The lead screw, nut, and barrel of each micrometer are calibrated as a unit at Eli Whitney Meterology Lab., and serial number is recorded.

Pyroceram Journal Bearings Pass Heat, Acid Lab Tests

CORNING, N. Y.—Pyroceram is suitable as a journal bearing material in some applications. Evaluation of the hard ceramic made from glass has indicated satisfactory performance in unlubricated high-temperature and in corrosive-lubricant applications.

Conducted for Corning Glass Works by an independent laboratory, test work led to several observations. In high-temperature testing where no lubricant was used, there was no evidence of seizure between Pyroceram (bearing) and Stellite Star J (shaft). Other shaft materials were compatible to lesser degrees. With Inconel, seizure was almost immediate. With M-2 tool steel, and Hastelloy C, there was no seizure during the 30-minute test, but the friction coefficient slowly increased. With Type 304 stainless steel and S-Monel, no seizure, but noisy operation.

With Pyroceram against stainless steel (304), Pyroceram, and Hastelloy B, and with lubricants of salt water, ferric chloride, citric acid, sodium hydroxide, molten lead, nitric acid, and hydrogen peroxide, only in three cases was surface wear appreciable. These cases were: Pyroceram-salt water, Hastelloy B-sodium hydroxide, and Hastelloy B-nitric acid.

Memory Tube Stores TV Picture for Hours

CLIFTON, N. J.—Information destined for a television picture tube or oscilloscope tube can be stored for hours in a new 1-in. diam storage tube announced by DuMont Laboratories, Inc.

Using electric read-in and read-out, the tube "writes" at 300,000 in. per sec to make itself particularly valuable for split-second studies. An independent read-out rate makes possible detailed analysis of results obtained. The tube can freeze information on one or more picture-tube displays at remote points, making it a useful tool where co-ordinated data-taking efforts are involved.

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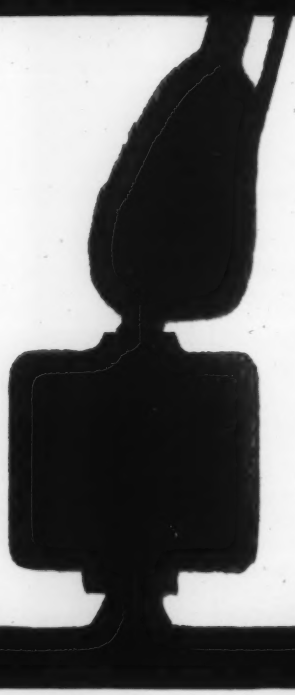

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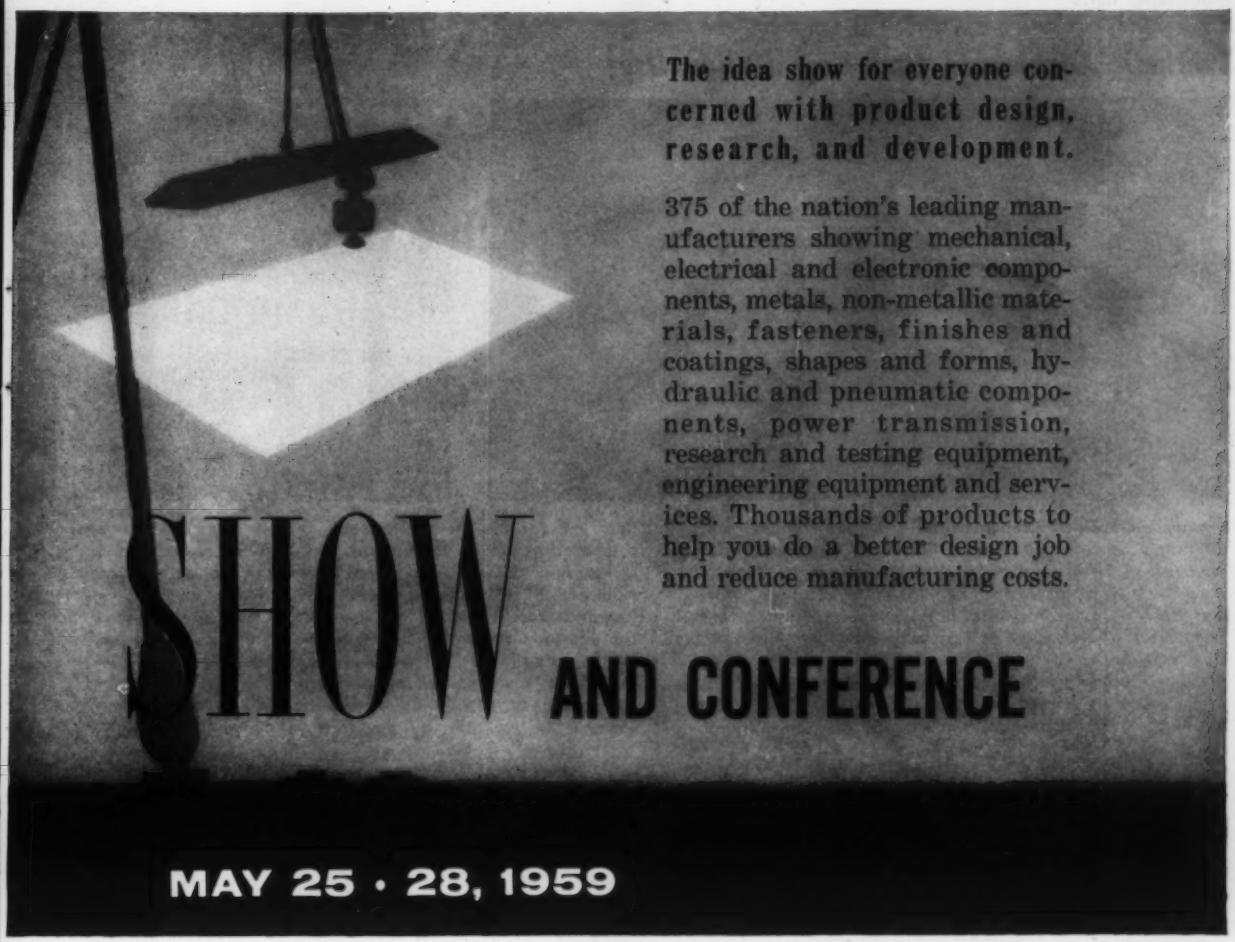
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Exhibitors in this show concentrate on displaying imaginative applications of their products to suggest design solutions.

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SAMPLES
Take home for trial and test actual samples of products you're interested in. Most often they're available in exhibitors' booths.

IDEAS
Your eyes will be opened to thousands of applications, suggestions, demonstrations, that can spark new thinking—speed your designs to a successful conclusion.

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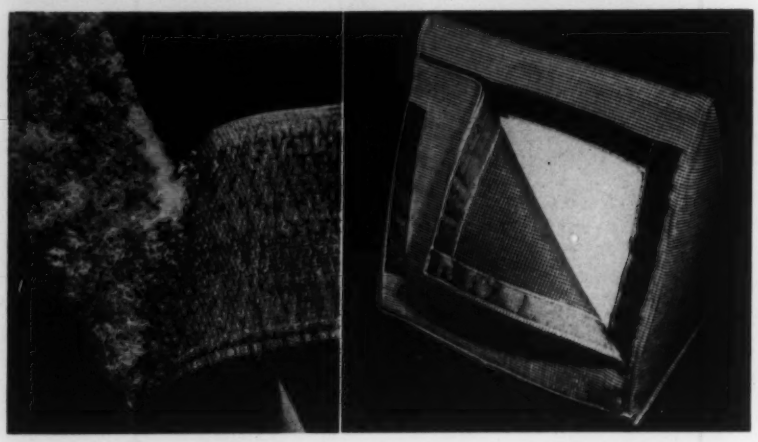
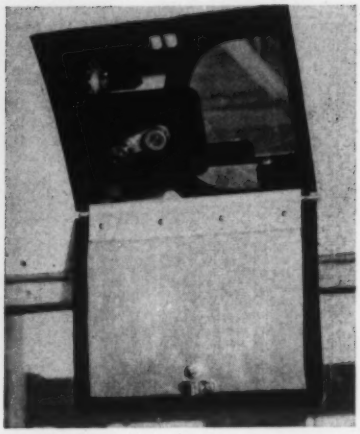
Synthetic Cockleburs Find New Design Uses





A tenacious new closure, patterned after the common burr, is finding unexpected uses in industrial fastener circles. More of a material than a device, the unique fastener consists of two strips of tough woven nylon tape. One strip, the male section, is covered with a myriad of stiff nylon hooks. The other section is covered with thousands of soft nylon loops. When the strips are lightly pressed together, hooks and loops engage to form a tight, adjustable closure. To open, the strips are merely peeled apart. Since hooks and loops are an integral part of the tape, they last for the life of the tape, and the closure can be opened and closed more than 30,000 times without loss of holding power. The nylon strips can be applied to cloth, metal, or other materials, by sewing, stapling, or bonding with a special adhesive. First industrial uses of the closure, shown above, include fastening removable covers on cushions in new airliners, and as a quick-operating cover fastener for metal destination-sign boxes on transit buses. Distributed by Velcro Corp., New York, the fastener is available by the yard in ½ to 2-in. widths.

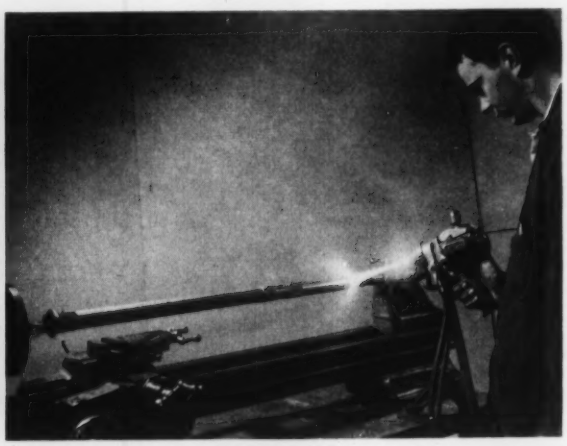
Metallized Aluminum Makes Durable, Light Parts

Reversing an Old Technique Plates Aluminum with Steel

CLEVELAND—The all-aluminum engine may have cylinder walls metallized by sprayed-on steel. Alcoa has been working with the Metallizing Engineering Co., Westbury, New York, on applications involving the use of molybdenum and steel to metallize aluminum. Recently the two companies co-operated with General Motors in a study of metallized piston and cylinder walls for an all-aluminum engine.

As a base for a steel metallizing coat, a 0.001-in. thick bonding coat of molybdenum is first sprayed on the aluminum. Then comes a 0.008-in. spray coat of steel. The finished product is machined or ground to leave a finish coat of 0.005 in. Hardness of Rockwell C-60 can be obtained by this process. In some applications, the metallizing material is nearly pure molybdenum.

Almost pure molybdenum will provide superior wear on the cylinder walls of this small two-cylinder engine. After spray coating, walls are ground to size.



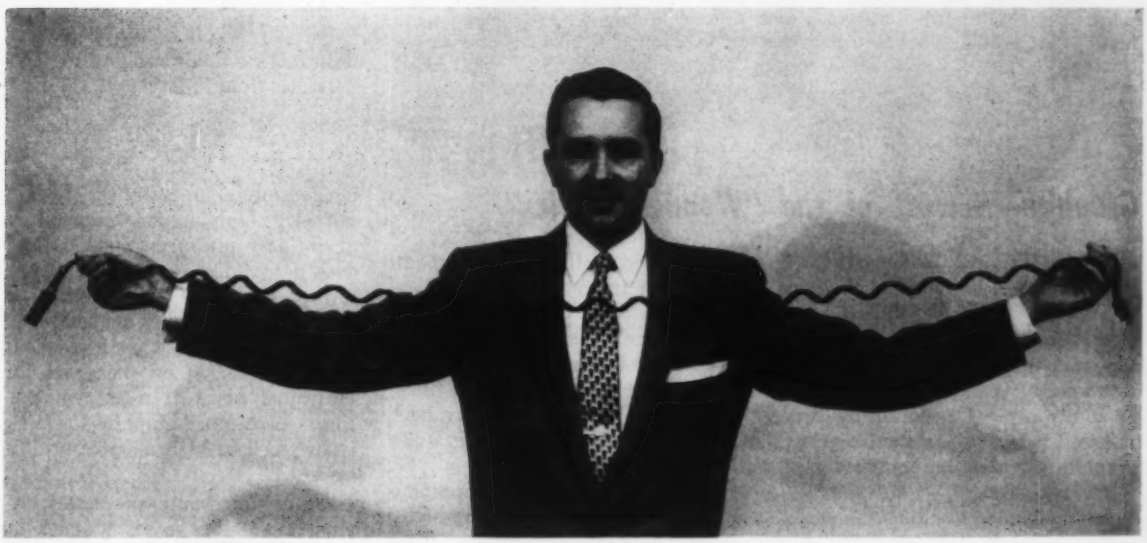
Torque tube for aircraft trim tab is made of aluminum. Bearing sections at both ends are metallized with stainless steel before press fitting into mating parts.

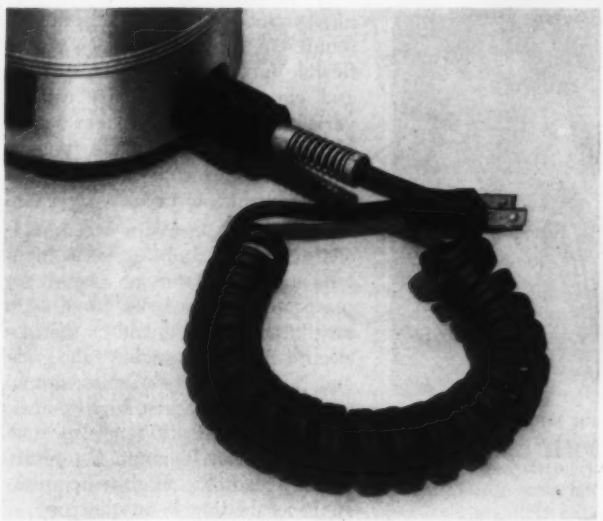
New neoprene-jacketed coiled heater cord unharmed by 500,000 stretches

This new neoprene-jacketed heater cord was designed with a built-in coil action that eliminates tangling and tripping hazards between small kitchen appliances and connecting outlets. Concerned with the possible ill effects of continued flexing, the manufacturer subjected it to an acceptance test of 500,000 stretch-and-recovery cycles. Following the test, a careful inspection of the flexed sample revealed no damage to the heater cord —no sign of failure in its neoprene jacket.

Long-term flexibility, the subject of this test, is just one of the advantages offered by the neoprene jacket on this new coiled appliance cord. Neoprene also provides good resistance to the harmful effects of heat, food chemicals, cooking oils, greases, and other common household agents that quickly attack ordinary jacketing materials.

Neoprene synthetic rubber, made by Du Pont for 25 years, has become a preferred material in the design and manufacture of many parts used by the appliance industry. Compressible gaskets, oil-resistant seals, flexible boots, durable wire jacketing . . . all benefit from its unmatched combination of important properties. Learn more about neoprene and the Du Pont family of synthetic rubbers. Write to E. I. du Pont de Nemours & Co. (Inc.), Elastomer Chemicals Dept. MD-4, Wilmington 98, Del.





Neoprene-jacketed coiled cord (type HPN) can be repeatedly stretched to its full length without affecting spring-back qualities or damaging the neoprene jacket.

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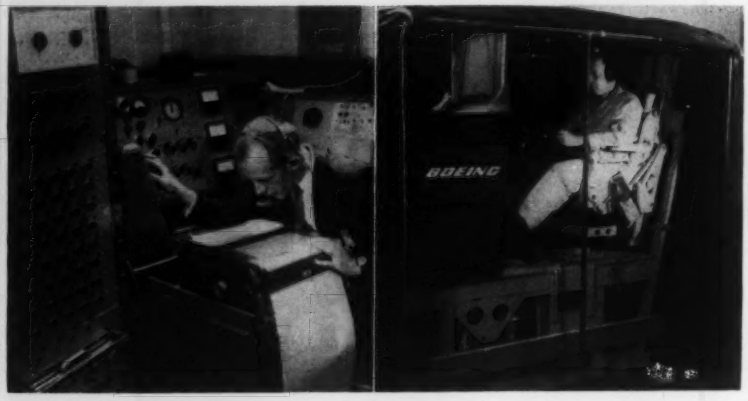


Computer "Flight Tests" Design Concept

Aircraft design can be tested for flight stability while still on the drawing board using this analog computer to determine its response to flying conditions. Pilot in mockup cockpit "flies" the ship using standard controls. Computer, programmed with basic flight characteristics determined on the design board, feeds information to a display screen simulating the view through the cockpit windshield. Display shows pitch, roll, and altitude in relation to a straight-line horizon; lateral displacement and heading in relation to runway boundaries. Emergencies like the loss of an engine are available complete with sound effects at the flick of a switch. Boeing Airplane Co. designed the device.

Contaminant Monitor Promises Pure Jet Fuel

BETHPAGE, N. Y. — An ultrasonic method of counting and measuring particle contaminants in flowing fluids promises jet-flight safety never before possible.

The device, developed especially for airborne fuel monitoring, can detect, count, and size entrained particles of 1 micron diam or larger. It can also halt flow, reroute the contaminated fluid through filters, and resume flow of pure fluid, all automatically.

According to Grumman Aircraft Corp. and Sperry Products Inc., complete monitoring of a flowing fluid will be possible in less than 1/40th the time formerly necessary to obtain and analyze a small sample.

Particle detection has been demonstrated in fluids ranging in temperature from −298 to 1050 F.

Graphite—Newest of the "Wonder Fabrics"

Textile Tailored Technically; No Function in World of Fashion

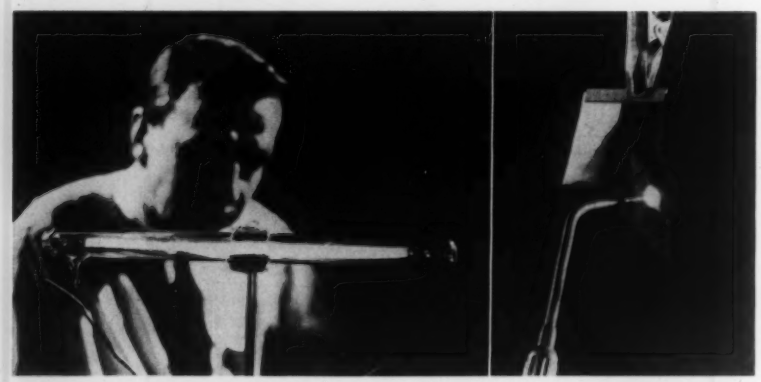
NEW YORK—One of the most versatile work-horse materials of modern technology has added a textile feather to its cap. Developed by National Carbon Co., manufactured graphite can now be produced as a felt, yarn, woven, or knit fabric.

In production, a fiber such as rayon is electrically heated to about 5400 F. A thermochemical conversion results, with the fiber's crystalline structure changed to that of graphite. Present production is 99.92 per cent pure graphite (0.08 per cent ash) in experimental quantities for consideration and evaluation by industry.

Among useful and important properties of graphite fiber are high-temperature characteristics. It does not melt (sublimation temperature at ordinary pressures: 6600 F) and does not oxidize in air at temperatures below 750 F. In addition, it gets stronger at higher temperatures; tensile strength at 4500 F is about twice the 15,000 psi measured for individual fibers at room temperature. Like other graphite forms, it is an excellent high-temperature lubricant.

Other important properties include the ability to resist attack by acids, alkalies, and all but the most highly oxidizing organics, and immunity to thermal shock (when in flexible form.) In addition, thermal and electrical conductivity can be varied over an appreciable range. Nuclear properties include the low neutron capture cross-section typical of all graphite forms.

Potential applications are numerous. A few include use as a high-temperature reinforcing agent for plastics and refractories (such as in missile nose cones), and as thermoelectric elements, vacuum-tube grids, and infrared emitters. Also, graphite fiber might become high-temperature self-lubricating gasket material, or even filaments for incandescent lamps. High-temperature conveyor belting is another use.



Narrow graphite cloth strip 10 in. long attains white heat when sealed in a vacuum and connected to a 110 v line, left. The incandescent strip radiates about 1300 watts. An oxyacetylene flame, right, is first passed over a strip of stainless-steel mesh and then onto a graphite cloth. The heat quickly melts the steel mesh, but causes only an incandescent glow on the cloth.

Noble Metal in Titanium Reduces Corrosive Action

Alloy Resists Corrosion from Reduction As Well As Oxidation

NIAGARA FALLS, N. Y.—Alloying titanium with only 0.1 per cent of palladium results in corrosion resistance to reducing acids like sulfuric or hydrochloric. There is no effect on titanium's excellent resistance to oxidizing chemicals such as nitric acid or ferric chloride, says Union Carbide Metals Co., who pioneered the process.

Many of the noble metals will give the beneficial result, but palladium was chosen for its low price. Mill products made with the new alloy will cost at most only 7 per cent more than the same products made of pure titanium. The discovery was made in testing a new theory on the role of noble metals in inhibiting galvanic action in the alloy.

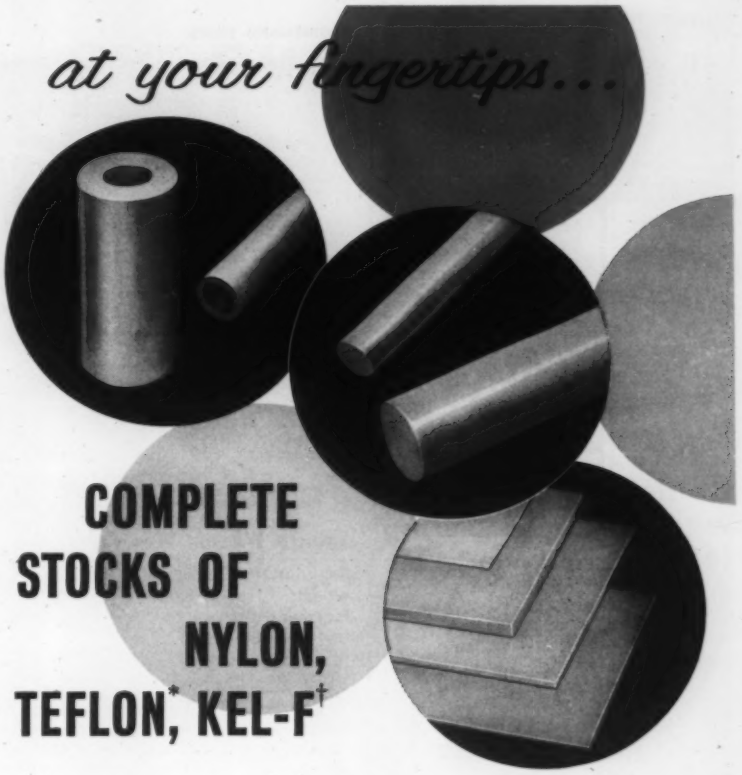
The new alloy opens the door for the use of titanium in piping, valves, and tubing where chemical corrosion is a problem. The qualities of titanium are unchanged except for the added corrosion resistance. In a boiling, 5 per cent solution of HCl pure titanium dissolves at the rate of 1 in. per year. The new alloy in the same circumstances loses 0.01 in. per year, an acceptable figure for many applications. Of the commonly used metals only tantalum has better resistance to both oxidizing and reducing agents.

Grease Burns Off To Deposit Solid Graphite Lubricant

PHILADELPHIA—A new lubricant for high-temperature application (1000 F or more) is a grease when handled, but a solid when working.

The grease consists of three components: A fine-particle graphite, a synthetic carrying agent, and an organic thickener. The carrier burns at high temperatures, depositing a soft graphite film. Loss of the carrier in no way affects lubricity.

At one demonstration, samples were actually burned to ash. The ash could immediately be spread into a smooth, tough film by light finger pressure.



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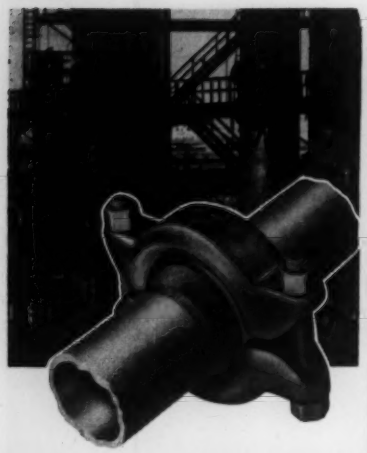

GRAYLOC Connections Hold High Pressures With No Leaks During 197,000 Loading Cycles

GRAYLOC connections in use at a Texas chemical plant* were cyclically loaded with pressures from 2,500 to 9,000 psi 197,000 times without a leak. Although these connections are rated at 12,000 psi, two of them were tested at maximum static pressure to learn whether fatigue action had changed the ultimate capacity. Both held at pressures far exceeding rating and one held without leakage to 27,000 psi.

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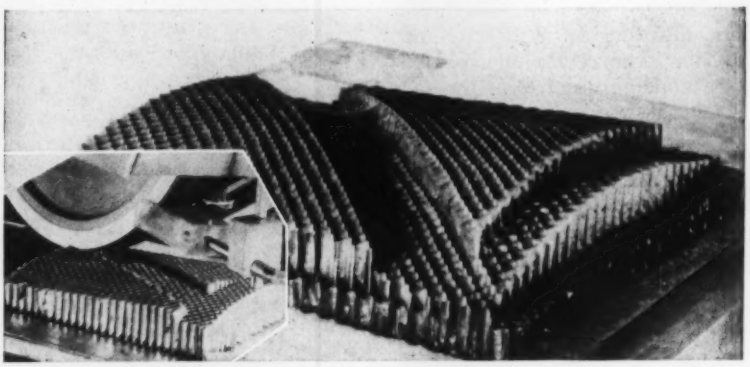
Circle 418 on Page 19

Square Wheels Win Prize

Superior traction in mud, sand, or snow is claimed for these prize-winning square wheels. Flat surfaces bridge ruts where round wheels sink in, claim proponents. Flats and corners can be in any relative position and the wheels do not have to be synchronized, yet they run "smoothly" up to 35 mph. They are designed for heavy trucks, jeeps, and farm machinery. Inventor Albert Sfredda won a $100 award in the J. S. Staedtler Inc. (Mars drafting pencils) 1959 design contest for the patented design. He reports no offers from Detroit as yet.



New Process Contours Honeycomb

Electrolytic machining of contour surfaces on honeycomb panels is possible with a new technique developed by Ekstrom, Carlson & Co., Rockford, Ill. Electrode wheel is guided by a tracer following a template. Resulting edge on honeycomb is clean and free of burrs ready for application of skin.

Lightweight Insulation Made from Glass Bubbles

NEW YORK — Tiny glass bubbles which resemble fine white sand can be used as filler with various binding materials—both plastic and ceramic—to make lightweight insulating parts. Properties besides light weight include low absorption, low leakage, low thermal conductivity, and high temperature stability. Typical applications for the bubbles, produced by Emerson and Cuming, Inc., Canton, Mass., include radomes (nonabsorbing shields for radar antennas), heat barrier material for encapsulating electric components, where they may be used in solid-casting resins or in foam, and lightweight ceramic insulators.

Wherever your customers buy MACOMA...

Its performance and name are the same around the world

Other Outstanding Shell Industrial Lubricants

Shell Tellus Oils—for hydraulic systems

Shell Alvania Grease—multi-purpose industrial grease

Shell Turbo Oils—for utility, industrial and marine turbines

Shell Rimula Oils—for heavy-duty diesel engines

Shell Talona R Oil 40—anti-wear crankcase oil for diesel locomotives

Shell Dromus Oils—soluble cutting oils for high-production metalworking

Shell Voluta Oils—for high-speed quenching with maximum stability

Shell Macoma Oils are available world-wide . . . assurance that your customers abroad will get the same performance from your equipment that your domestic customers rely upon.

Macoma® Oils are premium quality, fortified extreme pressure industrial gear oils. They provide superior high-load-carrying capacity and are particularly effective where overloading, severe shock-loading or general heavy-duty conditions exist.

Macoma Oils have these added built-in benefits: excellent resistance to oxidation, great adhesiveness, rapid separation from water. They are non-corrosive, non-foaming and have high stability in storage.

For more information, write Shell Oil Company, 50 West 50th Street, New York 20, New York, or 100 Bush Street, San Francisco 6, California. In Canada: Shell Oil Company of Canada, Limited, 505 University Avenue, Toronto 2, Ontario.

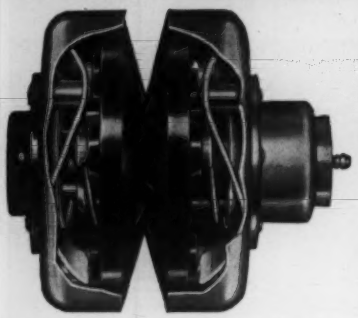
SHELL MACOMA OIL

the extreme pressure industrial gear lubricant

SHELL

Circle 419 on Page 19

Hi-Lo Load-O-Matic Control Eliminates Pulley Slow Down



Hi-Lo Variable Speed Pulleys positively maintain the desired speed ratio over a wide range of load variation by means of an exclusive cam and cam follower assembly. This means:

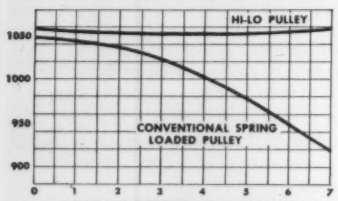
Pulley speed is independent of load and load changes. "Drag" is eliminated and high shock absorbency provided.

Pulleys do not compress belt due to spring pressure. Springs are not driving members. They act only to keep pulley faces in contact with belt.

Pulleys automatically regulate belt tension. Because of the cam assembly, belt is never under more tension than required by the load.

Double cams maintain constant belt alignment.

HI-LO PULLEYS COMPARED TO OTHER VARIABLE SPEED PULLEYS



PLUS THESE OTHER FEATURES:

- Smaller in size than comparable units.
- Quickly and easily installed.
- Replaceable face assemblies drastically cut repair and replacement costs.
- Available in sizes from .5 to 5 hp., ratios to 2.5/1 (single pulley) 6.25/1 (double pulley).

Request details and prices. Ask for Bulletin A-458.

Manufactured By HI-LO MANUFACTURING COMPANY

Nationally Distributed By LOVEJOY FLEXIBLE COUPLING COMPANY 4968-H W. Lake St Chicago 44, Ill.

Circle 420 on Page 19

Nine-Ton Peephole

Radiation shielding 8½ ft thick will protect observers at the National Reactor Testing Station near Idaho Falls, Idaho. Largest ever designed, the Corning Glass Works window contains seven separate glass panes, each 9 in. thick, and twelve plastic sheets. Window dimensions on the hot side are 31 by 64 in., and on the viewing side are 22 by 42 in. Despite appearance, there is only one man behind the shielding. Refractive effects account for the image.

Late Car Entry for '59

Eight passengers or a half-ton of cargo are load-carrying options in International Harvester's '59 Travelall. Standard powerplant for the utility vehicle is a 141-hp six. Optional equipment includes a 154-hp V-8 engine, automatic transmission, power steering, power brakes, and four-wheel drive. Stylewise, Travelall boasts the largest one-piece anodized aluminum grille in the industry. Full vinyl upholstery and 5-ft wide seats are interior styling features.

Russian-English Dictionary Readied for '60 Publication

ANN ARBOR, MICH.—First proposed at the 1956 Moscow mathematical congress, a Russian-English dictionary is being compiled at the University of Michigan for publication sometime in 1960. A joint U. S.-Soviet venture, the project will also result in publication of an English-Russian dictionary behind the Iron Curtain.

Under the direction of associate professor of mathematics A. J. Lohwater, 30 compilers have now completed a first draft consisting of about 12,000 words. The next step will be to confer with the Soviets on progress to date. A working proposal has been negotiated with the Soviet Academy of Sciences.

Circle 421 on Page 19 for Fittings→

PARKER-HANNIFIN FLUID-SYSTEM COMPONENTS

From HANNIFIN...

unit construction to give you air valves that do more jobs

Hannifin ⅜" four-way valve with "universal" base and new Speed Control section. Single-solenoid actuated, 10 other actuators available.

Hannifin's exclusive "spool-poppet" seals bubble-tight at either end of its short stroke.

For complete J.I.C. compliance, valve is electrically inoperative until dust-tight, [illegible] solenoid cover is replaced and fastened tightly. Result: no more clogged, jammed solenoids.

One of the versatile—and most popular—Hannifin air control valves is this "CC" series, single-solenoid model. It is available for either ¼" or ⅜" air lines and is gasket-mounted to its own base. This particular base (one of three choices offered) can either be O-ring gasketed to your manifold or mounted over an opening in your bracket or machine. It will receive all four lines from below or take the inlet line from below and the two cylinder lines out one side. Or, you can make all connections at the sides.

When it comes to actuation, Hannifin offers an even wider selection: hand, foot, cam, pressure, single or double solenoid.

When necessary, you can remove this entire valve from its base without disconnecting air lines. Or, the exclusive "spool-poppet" can be replaced without even breaking electrical connections.

The "CC" series, like all Hannifin valves, is designed with "full flow" internal passages as large or larger than its rated pipe size.

You will find these and most other Hannifin valves described in Hannifin's new "Valve Finder." Get your copy from your Hannifin man, listed in the A-Z volume of Thomas' Register, or write:

HANNIFIN COMPANY

525 South Wolf Road • Des Plaines, Illinois

A DIVISION OF PARKER-HANNIFIN CORPORATION

Now from Parker

BOTH permanent-end and re-usable hose assemblies

Parker "Krimp-lok" hose assemblies — supplied in a wide variety of fittings-and-hose combinations for any type of service and fluid.

A few of the wide range of Parker adapters available

You may require permanent-end hose assemblies for your production AND re-usable fittings with coils of hose for quick, trouble-proof replacements in the field. With the addition of Parker's new "Krimp-lok" fittings, permanent-end assemblies are now available from Parker. They use the same Parker hoses that enjoy a wide acceptance when used with Parker *no-skive* "Hoze-lok" fittings in the replacement field.

A full range of Parker adapters is also available.

Ask your Parker Hose Distributor, listed in the Yellow Pages, for engineering advice and literature on "Hoze-lok" re-usable fittings, also Parker hose and adapters. Write us in Cleveland regarding your requirements for Parker "Krimp-lok" Hose Assemblies.

Parker

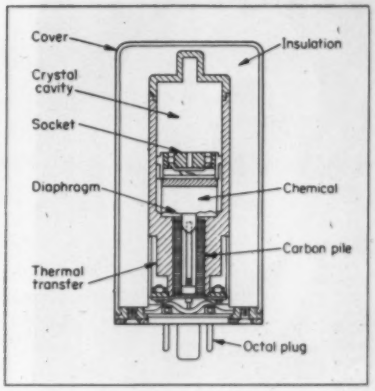
FITTINGS AND HOSE DIVISION

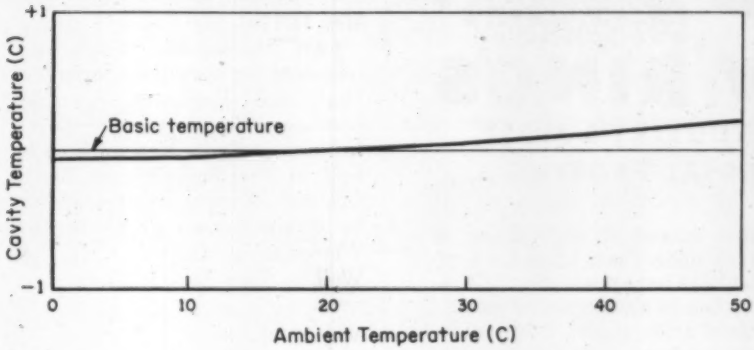
17325 Euclid Avenue

Cleveland 12, Ohio

Chemical Thermostat Holds Temperature Constant

Partial changes between liquid and solid state in a eutectic constant-temperature bath absorb or release heat to maintain temperature in a crystal cavity within ¼ deg C over a range of 50 C ambient temperature change. Volume changes between liquid and solid move the diaphragm to change pressure on the carbon pile, making a corresponding change in the flow of electric current to heat the assembly. The unit was developed by Robertshaw-Fulton Controls Co.





38 Billion Light-Years Coming into Rapid Focus

ROANOKE, VA.—With clearing and grading of the Sugar Grove, W. Va., site about finished, the world's largest radio telescope is right on schedule.

A 60-ft pilot model is currently being fabricated for erection in the late spring. Structural steel for the main telescope is also being fabricated, says U. S. Steel Corp.

Able to gaze an estimated 38 billion light-years out, the telescope will "see" and "hear" objects nineteen times farther out than the 200-in. optical telescope at Mount Palomar, Calif. Presently, the world's largest radio telescope is a 350-ft diam parabolic-reflector unit located behind the Iron Curtain. The Free World's largest is at Jodrell Bank, England, and has a 250-ft diam reflector.

Specific dimensions for the new American radio telescope have not yet been released. For an indirect comparison, however, the Jodrell Bank telescope was designed to probe 1 billion light-years into space (MD Sept. 19, 1957, p. 25).

The instrument will be a Navy research tool for radio communications as well as for radio astronomy.

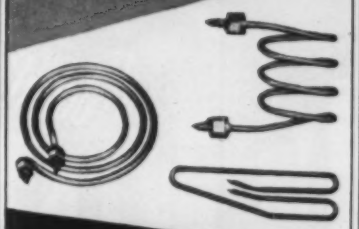
Inert Lubricant Forms Metal Shield

FORT WORTH, TEX.—With the successful completion of a two year field test program, Almasol has come of age. Able to withstand 1900 F, and attack by all types of acids, the lubricant literally shields metal parts from wear.

Derived from an aluminum-magnesium silicate (hence, Almasol), its unusual properties are due to chemical inertness and adhesive tendencies for metals. After electrostatic purification to remove all abrasives, the soft tan powder will not react with any acid, and adheres to metal in a thin layer. Bonds are so strong that grinding is required to separate them.

Other layers of the powder slide

VULCAN TUBULAR HEATERS



In the best of shapes

Here are just a few of the many shapes to which Vulcan Electric Tubular Heaters are formed. They are ideal for immersion in liquids, soft metals or molten salts. Straight, tubular heaters are easily clamped to metal surfaces or inserted in machined grooves. Vulcan Tubulars are easily cast into aluminum, iron or other metals. They can also be furnished with flattened surface for even more efficient heat transfer.

Vulcan Tubular Heaters are especially useful when you want a lot of heat in a little space. You have a wide choice of sizes — 10″ to 148″ (special — shorter or longer); diameters — .250″, .280″, .333″, .450″; wattage — 10 to 10,000 (or higher); voltage — standard 120 or 240, special 6 to 480 (or higher); sheaths — copper, steel, high temperature alloys.

Solve your hot problems with *Vulcan Versatility* in electric heat. Send coupon for catalog and prices.

VULCAN ELECTRIC COMPANY
Danvers, Mass.

Cartridge • Strip • Tubular • Immersion Electric Heaters
Soldering and Branding Irons • Solder and Glue Pots

Vulcan Electric Company
6 Holten Street, Danvers, Mass.
Please send me catalog and price information on Vulcan Electric Heaters.

Name & Title.....
Company.....
Street & No.....
City & State.....

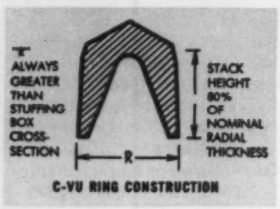
Circle 423 on Page 19

←Circle 422 on Page 19 for Air Valve Finder

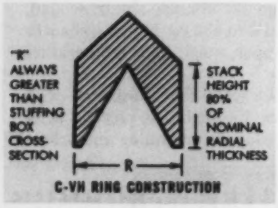
Countless successful applications of C-V Rings under the most severe service conditions have made this the closest approach to a universal packing.

It will effectively handle all industrial acids, alkalis, solvents, organic and hydraulic fluids . . . temperatures from −120°F. to +500°F. . . . is equally suited to valves, pumps, mixers, hydraulic cylinders and like equipment.

"John Crane" C-V Rings have extremely low coefficient of friction. "Breakout" friction is only slightly higher than running friction.



C-VU RING CONSTRUCTION



C-VH RING CONSTRUCTION

TWO STYLES ARE AVAILABLE:

C-VU RINGS ***for low pressure service*** —such as control and regulator valves handling gases and fluids, where it is necessary to have a very sensitive and resilient type packing.

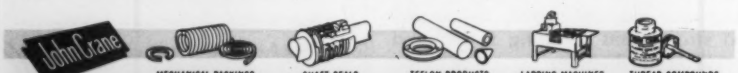
C-VH RINGS ***for high pressure service*** —for use in pumps, hydraulic cylinders and like services at pressures ranging to 500 psi. and over. These rings are constructed with a heavy wall heel to withstand pressure requirements. They are designed to provide voids between rings, so that as the Teflon expands due to heat, this take-up room minimizes any excess friction in the stuffing box.

"John Crane" C-V Rings are available in full line of standard sizes and male and female adaptors. Sizes can be molded to stuffing box specifications.

Request Bulletin P-325.

*"John Crane" C-V Rings are made from Chemlon—*the best in DuPont Teflon.*

Crane Packing Co., 6425 Oakton St., Morton Grove, Ill. (Chicago Suburb). *In Canada: Crane Packing Co., Ltd., Hamilton, Ont.*



CRANE PACKING COMPANY

across the bonded layer. With the thin shield, the metal is impervious to corrosion and to acid attack.

Patent and distribution rights were assigned to Lubrication Engineers Inc., in 1956, by the group that patented the product.

Meetings

AND EXPOSITIONS

May 11-13—

Joint Automation Conference, sponsored by American Society of Mechanical Engineers, American Institute of Electrical Engineers and Institute of Radio Engineers, to be held at the Pick-Congress Hotel, Chicago. Further information can be obtained from F. D. Snyder, Westinghouse Electric Corp., 40 Wall St., New York 5, N. Y.

May 12-14—

American Society of Mechanical Engineers. Production Engineering Div. Conference to be held at the Statler-Hilton Hotel, Detroit. Additional information is available from society headquarters, 29 W. 39th St., New York 18, N. Y.

May 13-14—

Porcelain Enamel Institute. Mid-Year Conference to be held at the Edgewater Beach Hotel, Chicago. Additional information can be obtained from PEI headquarters, Associations Bldg., 1145 Nineteenth St. N. W., Washington, D. C.

May 15-18—

National Fluid Power Association. Spring Meeting to be held at the Grove Park Inn, Asheville, N. C. Additional information is available from NFPA headquarters, 1618 Orrington Ave., Evanston, Ill.

May 18-20—

Instrument Society of America. Fifth Annual Symposium on Instrumental Methods of Analysis to be held at the Shamrock-Hilton Hotel, Houston, Tex. Further information can be obtained from ISA, 313 Sixth Ave., Pittsburgh 22, Pa.

May 20-22—

Society for Experimental Stress Analysis. Spring Meeting to be held at the Sheraton-Park Hotel, Washington, D. C. Additional information is available from R. O. Belsheim, 2475 Virginia Ave. N.W., Apt. 514, Washington 7, D. C.

May 25-27—

American Society for Quality Control. Annual Convention and All Industry Production & Quality Control Exposition to be held at Public Auditorium, Cleveland. Further information is available from society headquarters, 161 W. Wisconsin Ave., Milwaukee 3, Wis.

May 25-28—

Design Engineering Show and Conference to be held at Convention Hall, Philadelphia. Conference is sponsored by the Machine Design Div. of ASME. Further information can be obtained from Clapp & Poliak Inc., 341 Madison Ave., New York 17, N. Y.

June 4-5—

Institute of Radio Engineers. Third National Conference of the Professional Group on Production Techniques to be held at the Villa Hotel, San Mateo, Calif. Further information is available from William C. Estler, 965 Lincoln Ave., Palo Alto, Calif.

June 9-11—

Material Handling Institute's Exposition of 1959 to be held at the Public Auditorium, Cleveland. Technical sessions are sponsored by the American Material Handling Society Inc., with the co-operative endorsement of the Society of the Advancement of Management and the American Society of Mechanical Engineers. Further information is available from MHI headquarters, Suite 759, 1 Gateway Center, Pittsburgh 22, Pa.

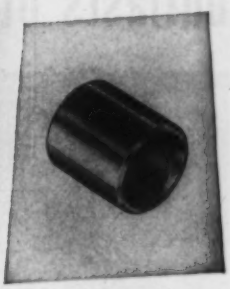
June 14-18—

American Society of Mechanical Engineers. Semiannual Meeting to be held at the Chase-Park Plaza Hotel, St. Louis. Further information is available from ASME headquarters, 29 W. 39th St., New York 18, N. Y.

ARE YOU GETTING

BUSHED CENTER LINKS
for greater fatigue life, easy assembly.

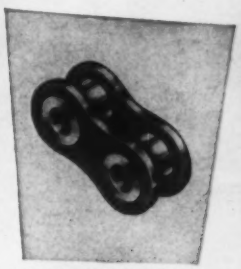
SPECIAL PINS
for high shock, abrasive or corrosive conditions.



SOLID ROLLS
for high impact resistance.

WHITNEY COMPONENT

SINTERED STEEL BUSHINGS
for drive self-lubrication.



SPECIAL ROLLER LINKS
for greater transmission capacity.

SHOULDERED BUSHINGS
for stability under high loads.

ENGINEERING SERVICE

. . . TO MEET YOUR DRIVE NEEDS?

Adapting standard roller chain to solve unusual or extreme drive problems is one example of Whitney's creative engineering service.

Here's how it works:

By combining **standard** chain parts with special fatigue, high load, impact, shock, corrosion or wear-resisting components, Whitney has solved many "problem" conditions, **without sacrificing drive interchangeability.**

Here are a few ways this Whitney service can help you:

- Provide greater transmission capacity without expensive equipment re-design.
- Assure acceptable drive service life under unusual high shock or load conditions.
- Maintain same transmission capacity within reduced space.
- Increase drive service life in corrosive or abrasive environments.

Your Whitney Field Engineer will gladly explain how this creative engineering can be selectively applied to your present design or equipment. Call him any time.

Write for helpful, practical Whitney literature.

Visit us at the Design Engineering Show—Booth # 1509

Whitney
CHAIN COMPANY

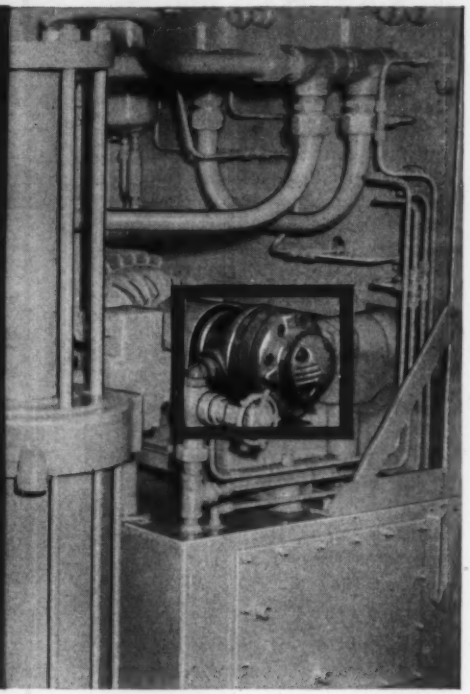
A SUBSIDIARY OF FOOTE BROS. GEAR AND MACHINE CORPORATION

411C HAMILTON STREET • HARTFORD 2, CONN.

ROLLER CHAIN • CONVEYOR CHAIN • SPROCKETS • FLEXIBLE COUPLINGS • WHITNEY-TORMAG DRIVES

Circle 425 on Page 19

New Series 800 GEROTOR from Brown & Sharpe outlasts other pumps in pumping fire-resistant fluids



Tests by a leading manufacturer led to the specification of Series 800 Gerotor Pumps for this and similar power units . . . developed for a welding application.

. . . These independent user tests prove it!

TEST BY COMPANY A*: Continuous-operation comparison with widely-used competitive pump, using identical test stands and special fluid for welding applications. Operating pressure, 600 psi.

Results: Competitive pump was worn out after 325 hours — delivering only 4% of original capacity (96% slippage) — failed to maintain pressure of 500 psi. Gerotor pump was operating as efficiently as when new!

TEST BY COMPANY B*: Series 800 Gerotor Pump operated satisfactorily for a 1000 hour test period at 1000 psi on glycol-water mixture — no significant wear or efficiency change.

TEST BY COMPANY C*: Series 800 Gerotor Pump operated satisfactorily for a 2000 hour test period at 900 psi on water-oil emulsion — no significant wear or efficiency change.

**Company names will be supplied upon request.*

Brown & Sharpe

HYDRAULICS DIVISION

GEAR, VANE AND CENTRIFUGAL PUMPS
DOUBLE A VALVES
GEROTOR PUMPS
POWER UNITS

B·S

PROGRESS IN PRECISION FOR OVER 125 YEARS

Many leading companies now specify Series 800 Gerotor Pumps for use with fire-resistant fluids such as: proprietary water-soluble-oil emulsions, either regular or inverse; ethylene glycol-water mixtures; phosphate ester types; and high-temperature MIL fluids.

Series 800 Gerotor Pumps are *another* development from Brown & Sharpe's expanded Hydraulics Division. They're available to you, along with other superior hydraulic products — through 55 offices in principal cities. Contact your nearest Brown & Sharpe sales representative. Or, write to Double A Products Co., a subsidiary of Brown & Sharpe Mfg. Co., Manchester, Mich.

Working on any of these design improvements

RELATED TO TORQUE TRANSMISSION? .... *more capacity*

greater angles

no torsional vibration

higher speeds

longer shaft life

extended bearing wear

If so, and if your application warrants placing the solution and ultimate cost-savings above ordinary, lower priced joint designs . . . RZEPPA can help you. Here's why:

By transmitting a uniform flow of power through ball bearing action, RZEPPA *Joints operate with less friction; carry heavier loads and are more compact than any other type of joint . . . size for size.*

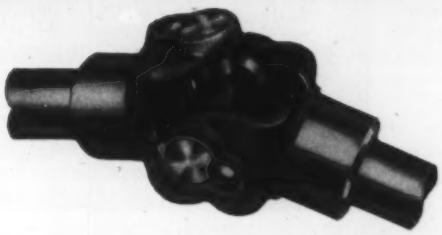
RZEPPA Constant Velocity Joints are available for *light, medium* and *heavy* duty on air and space craft, vehicles and industrial machinery.

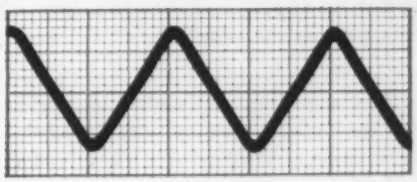
WRITE FOR LATEST LITERATURE or send your dimensional sketch with peak horsepower, R.P.M. and operating angles. Without obligation, our engineers will assist you. Address: THE GEAR GRINDING MACHINE COMPANY, Dept. DJ-459, 3901 Christopher St., Detroit 11, Michigan.

RZEPPA CONSTANT VELOCITY UNIVERSAL JOINTS

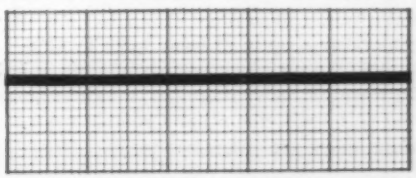
(PRONOUNCED: "SHEPPA")

Genuine RZEPPA Joints are made exclusively by THE GEAR GRINDING MACHINE CO.





ORDINARY CROSS OR PIN UNIVERSAL JOINT — Mathematics and geometry prove this joint changes velocity of the driven shaft with two high points and two low points per complete revolution. This fluctuating torque action causes vibration and wear throughout entire driving mechanism.



CONSTANT VELOCITY JOINT — This RZEPPA design joint *always* transmits smooth torque even at unbalanced angles. Such smooth torque action results from ball bearings applying power in a plane that bisects both shaft axes.

Memo on Metals

New Age-hardenable Titanium Alloys Offer Up to 220,000 psi Tensile Strength and Easier Formability for 600 to 1,000 F Applications

Three new age-hardenable titanium alloys may prove to be the solution to many of the strength-weight and temperature problems encountered in designing advanced aircraft and missiles. They may also prove extremely economical for such applications.

All three offer much higher strengths than other titanium alloys – and have the light weight and corrosion resistance typical of titanium alloys. Furthermore, they are readily FORMAGEABLE* – capable of being formed in the solution-treated or "soft" condition and then strengthened by simple thermal aging techniques. Each is now in pilot production and available in limited quantities of mill products.

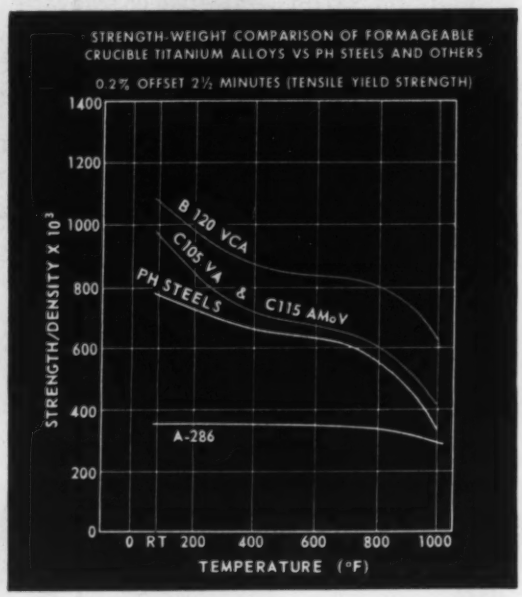
First Age-hardenable All-beta Ti Alloy

Crucible B-120VCA is the first useful titanium alloy with an all-beta (high temperature) structure. It has both the highest strength and best formability of any titanium-base alloy.

This alloy's composition (13%V-11%Cr-3%Al) enables its structure to stay all-beta during forming and/or during slow cooling, and to age to high strength levels at temperatures where distortion is not a problem.

B-120VCA has a unique combination of properties. Room temperature strengths of 200,000 to 250,000 psi have been obtained. On a strength-weight basis this is the highest strength of any available structural material. In short-time elevated temperature tensile tests (1-2 minutes), it offers a decided strength-weight advantage over alternate materials at temperatures up to at least 1,000 F. Under creep conditions, for very long periods of time, it enjoys a strength-weight advantage up to at least 600 F. Beyond this limit, the other Crucible FORMAGEABLE titanium alloys are recommended.

B-120VCA is ductile-weldable, cold-headable, and has great and deep hardenability. Because of this formability, it should prove suitable for applications such as aircraft skins, stiffeners and other primary structural shapes, and for missile pressure tanks, rocket motor cases and structural members. Preliminary tests indicate it may prove unequalled as a construction material for honeycomb assemblies. Because it is so easy to cold-head, it has a large potential in such items as rivets.



Alpha-beta Titanium-base Alloys

Crucible C-105VA is an alph-beta titanium-base material which also is FORMAGEABLE. Its 16% vanadium content stabilizes a sufficient amount of the beta phase for good age-hardenable response; the 2.5% Al content improves the alloy's elevated temperature properties.

C-105VA resolves two conflicting requirements for aircraft sheet material. It is soft, ductile and easily formed in the solution-quenched condition. Because the formed parts can be aged subsequently at moderate temperatures, parts made of C-105VA can possess high strengths at temperatures up to 800 F for long periods of time.

* *age-hardenable titanium alloys*
* *tool steels in production parts*
* *borated stainless steels*

This third alloy, C-115 AMoV (4%Al-3%Mo-1%V), also shows considerable promise for aircraft sheet applications. It is age-hardenable to higher strengths than C-105VA with only slight sacrifice in forming characteristics.

Considerable data on the properties and fabricating qualities of all three alloys have been assembled by Crucible's Titanium Division. For data sheets and additional information, send the coupon.

Tool Steels Replace Standard Alloys for Production Parts

As design and metallurgical engineers require materials with improved properties or greater uniformity, they are turning more to the use of tool steel for production parts. Here are three good examples:

1. Vanes in the hydraulic system that actuates the automatic steering mechanism on cars are made of Crucible REX® M-2 high speed steel. REX M-2 combines the abrasion resistance necessary for minimum wear with the impact resistance needed for long life and safety. The manufacturer experimented with numerous other steels, but high speed steel lasted longer than any other type tested.

2. Actuator bars for a nationally-known calculator are now being produced of Crucible KETOS® – a low-priced AISI Type O1 alloy tool steel – because the thin, close-tolerance contact edges withstood over 4-million high speed blows in a life test. No other steel has lasted more than 1-million cycles before chipping and failing.

3. Cylinder block for a fast acting, aircraft hydraulic pump made of Crucible Chrome tool steel. Pump operates at temperatures up to 500 F, pressures to 5,000 psi. Tool steel was selected over a standard AISI alloy because of its high degree of cleanliness, uniform response to heat treatment, and controlled hardenability. Furthermore, because tool steel practices are employed in making it, the steel more consistently meets the critical mechanical and physical properties required in this application.

For data sheets on these and all other Crucible tool steels – send the coupon.

High Boron Stainless Steels Made Possible by Vacuum Melting

Type 304 stainless steel with boron has proved to be an excellent material for nuclear equipment, because the boron readily absorbs neutrons. By increasing the boron content, valuable weight and thickness reductions can be made in reactor shielding and control rods.

Unfortunately, conventionally melted borated 304 becomes "hot short" – virtually impossible to work if the boron content exceeds 1%. Vacuum melting has provided the answer to this problem. Vacuum-melted 304 stainless is readily workable when the boron content goes up to 2% or even higher.

Vacuum melting the alloy also provides closer control of the composition, because only pure materials are used. So, undesirable elements such as cobalt – which becomes radioactive upon bombardment – can be kept to a minimum. In fact, vacuum-melted Type 304 stainless can be supplied with less than .001% cobalt.

For additional information on vacuum-melted steels – send the coupon.

CRUCIBLE STEEL COMPANY OF AMERICA
Dept. ED07, The Oliver Building
Mellon Square, Pittsburgh 22, Pa.

Gentlemen:
Please send me the following:
1. Data sheets on B-120VCA ☐ C-105VA ☐ C-115AMoV ☐
2. A copy of "Titanium Alloys for Aircraft and Spacecraft" by Finlay, Vordahl and Malone ☐
3. Data Book on Crucible tool steels ☐
4. Data sheets on vacuum-melted steels ☐

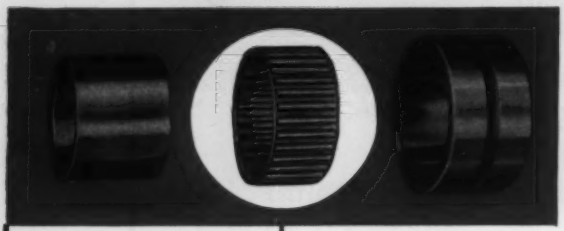
Name_____ Title_____
Company_____
Street_____
City_____ Zone____ State_____

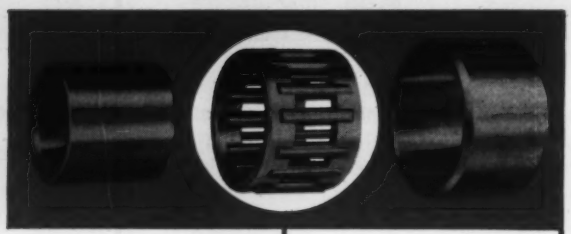
CRUCIBLE STEEL COMPANY OF AMERICA

*Reg. Trade Mark

Circle 428 on Page 19

ORANGE "Packaged" Cage-and-Roller Assemblies
offer many Design, Space and Cost Advantages





USE THEM TO:

——meet space restrictions in applications such as idler gears, planetary gears, seaming rolls or any locations where shaft and housing surfaces can be hardened and ground.

——save cost of separate races, and reduce space.

USE THEM TO REPLACE:

——full complements of loose rollers.
——thin-shell needle bearings.
——sleeve bearings.

OPERATING ADVANTAGES:

——highest precision operation.
——high load in small space.
——cage-guided rollers can not skew or misalign.
——may be selected for special clearance requirements.

ORANGE NEEDLE ROLLER-CAGE ASSEMBLIES

Utilize 1/8" diameter precision ground rollers, permanently aligned in pockets of bronze cages centered on housing surface. These compact units are available in 18 sizes from 1/2" to 2" shaft diameters, in a choice of two lengths for each shaft diameter.

ORANGE JOURNAL ROLLER-CAGE ASSEMBLIES

Consist of long, large diameter precision rollers retained in two machined bronze cage ends, rigidly aligned by fitted steel pins. Provide a rugged, space-saving, self-contained roller-cage assembly. Available in 26 sizes from 5/8" to 4 1/2" shaft diameters, in up to five lengths for each size.

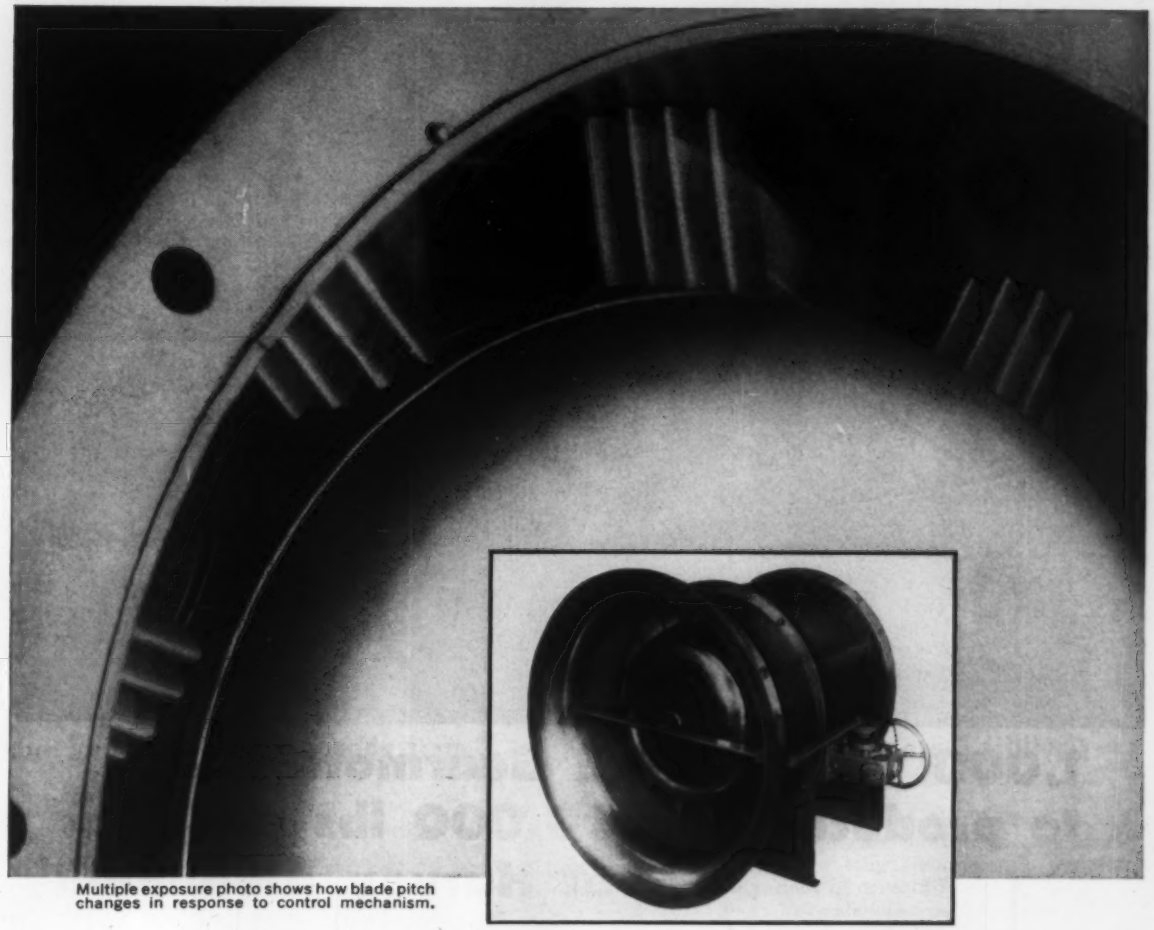
See the complete line of Orange Roller Bearings at BOOTH 1352, DESIGN ENGINEERING SHOW

Write for further details, dimensions and prices on Orange Cage-and-Roller Assemblies

ORANGE ROLLER BEARINGS

ORANGE ROLLER BEARING CO., Inc.
556 Main Street, Orange, N. J.

Needle Bearings — Staggered Roller Bearings
Journal Roller Bearings — Thrust Roller Bearings
Cam Followers



Multiple exposure photo shows how blade pitch changes in response to control mechanism.

Automatic Adjustment of Air Supply to CO_2 Concentration, Temperature or Humidity with Joy Controllable Pitch Axivane® Fans

The blade pitch on Joy Axivane Fans can be changed automatically while the fan is running, varying the air volume as much as ±20%. The controlling mechanism can be linked to a sensing device to make air volume respond to a change in ambient temperature, humidity, concentration of a gas, or any of a number of conditions.

Controllable Pitch Joy Axivane Fans are ideal for ventilation of vehicular tunnels and work areas in which noxious gases tend to collect, maintaining air cooled equipment at an even temperature, stabilizing moisture content in an area, or any application requiring a variable supply of ventilation air.

Write for complete details on how Joy Controllable Pitch Axivane Fans can be made to suit your particular situation. Ask for bulletin 289-64B.

AIR MOVING EQUIPMENT FOR ALL INDUSTRY

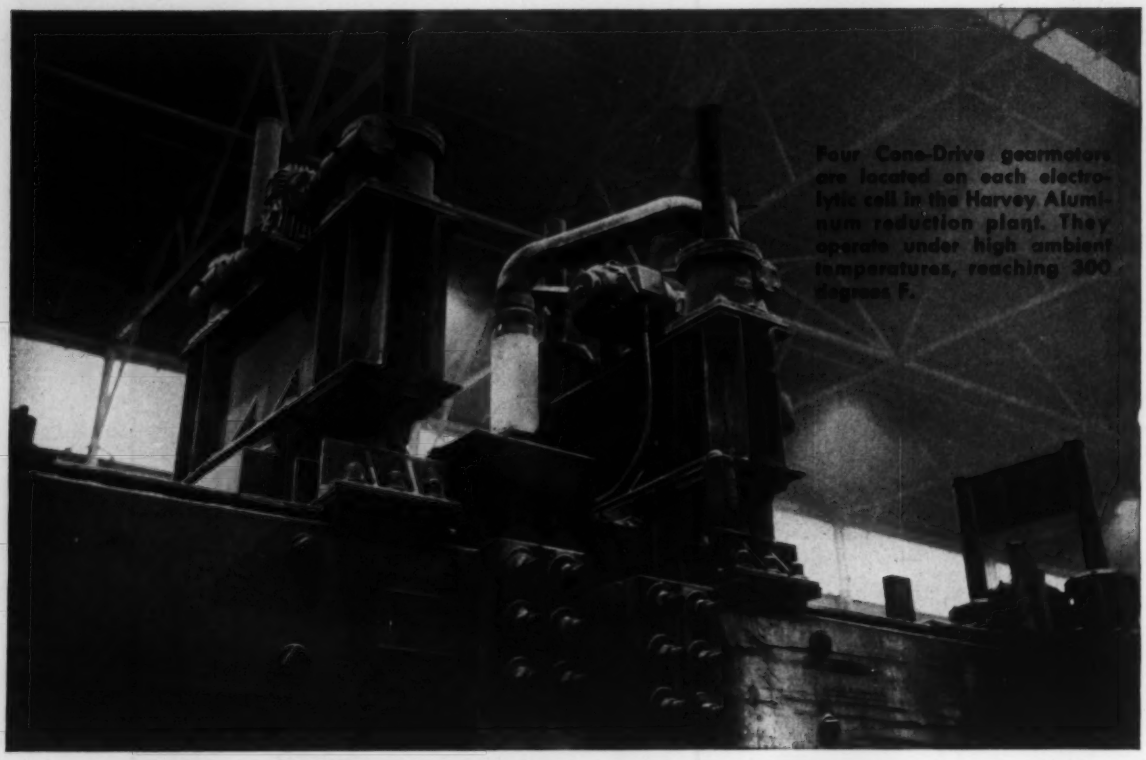
JOY

Joy Manufacturing Company
Oliver Building, Pittsburgh 22, Pa.

In Canada: Joy Manufacturing Company (Canada) Limited, Galt, Ontario

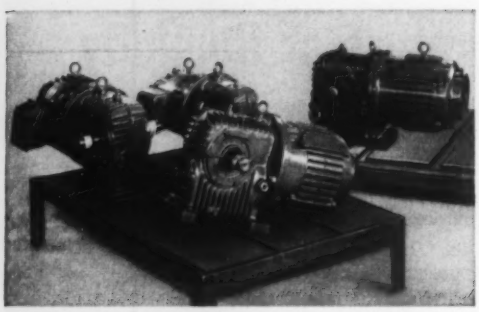
WSW I 7482-289

Circle 430 on Page 19



Four Cone-Drive gearmotors are located on each electrolytic cell in the Harvey Aluminum reduction plant. They operate under high ambient temperatures, reaching 300 degrees F.

1,000 CONE-DRIVE Gearmotors to produce 100,000,000 lbs per year at Harvey Aluminum



Four double-enveloping worm gearmotors used by Harvey Aluminum are shown here after test run in Cone-Drive plant. They were palletized in groups of four for shipment to Oregon smelter.

From its modern reduction plant at The Dalles, Oregon, Harvey ships primary aluminum in pig, ingot and billet forms all over America. The smelter includes the latest and most efficient equipment and operating techniques. Reflecting this modern equipment are 1,000 Cone-Drive double-enveloping worm gearmotors, used to control the height of anodes and casings in relation to the molten aluminum bath in each of the electric furnaces. Annual capacity is more than 100-million pounds.

The gearmotors are operated under high ambient temperatures that reach 300° F. This was an important consideration in Harvey's selection of Cone-Drive gearmotors. In addition, the ability to withstand the full force of stalled driving motors and constant reversing operations figured in Cone-Drive gearing's selection.

Cone-Drive double-enveloping worm gearmotors are available in a wide variety of styles and sizes. Models include standard shaft or hollow shaft with worm over or under or gearshaft vertical. Capacities range from ¼ to 40 HP and reductions from 3.3:1 to 240:1. Ask for Catalog No. 58 for complete specifications.

CONE-DRIVE GEARS DIVISION MICHIGAN TOOL COMPANY

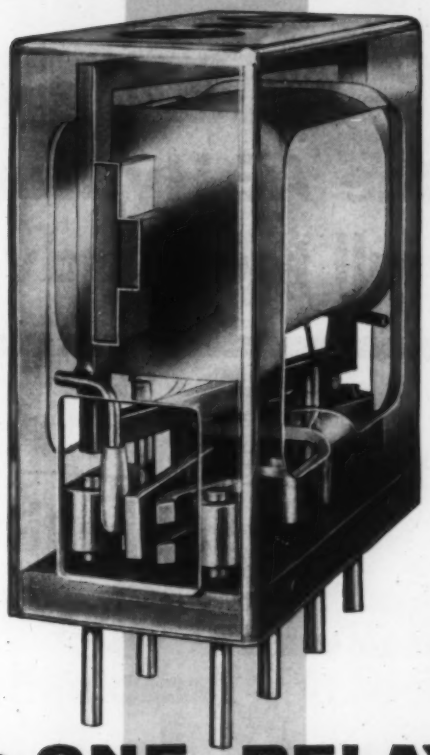
7171 E. McNichols Road • Detroit 12, Michigan • Telephone: TWinbrook 1-3111

DOUBLE-ENVELOPING WORM GEARSETS

DOUBLE-ENVELOPING WORM GEAR SPEED REDUCERS

DOUBLE REDUCTION WORM GEAR SPEED REDUCERS

DOUBLE-ENVELOPING RIGHT ANGLE GEARMOTORS



4 times actual size

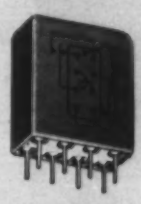
Mock-up of CLARE Type F Relay enlarged to show operating mechanism. Note bifurcated contacts which enable this relay to handle a wide variety of contact loads.

With this ONE RELAY

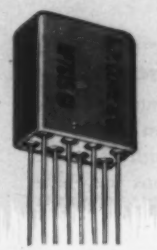
You can handle contact loads from 3 amperes down to 1 microampere, 1 millivolt

SPECIFICATIONS

Ambient Temperature	–65° C to +125° C.
Shock	65 Gs for 11 milliseconds.
Vibration	5-75 cps at maximum excursion of ¼ inch, 75-2000 cps at 20 Gs acceleration.
Dielectric Strength	Sea level—1000 volts rms between terminals and frame, and between adjacent circuits; 750 volts rms between contacts of a set. At 80,000 ft., 350 volts rms.
Insulation Resistance	1000 megohms minimum at 125° C.
Coils	Coils up to 10,000 ohms available for a wide range of voltage or current operation.
Nominal Operating Power	250 milliwatts.
Pickup Time	3.5 milliseconds nominal.
Dropout Time	1.5 milliseconds nominal.
Contact Arrangement	2 pdt (2 form C).
Contact Rating	3 amps resistive at 28 volts d-c or 115 volts a-c; also will handle loads of 1 microampere @ 1 millivolt reliably.
Contact Resistance	0.03 ohm maximum.
Contact Life	500,000 operations minimum at 2 amps; 100,000 operations minimum at 3 amps; 1,000,000 operations minimum at 1 amp.
Enclosure	Hermetically sealed, filled with dry nitrogen at 1 atmosphere pressure.
Mounting	All popular mounting arrangements available.
Terminals	Printed circuit; solder; plug-in (matching socket available). Variations of printed-circuit terminal length on 1/10-inch grid spacing available.
Weight	17 grams.
Military Specifications	MIL-R-25018, except as to contact bounce.



ACTUAL SIZE
All popular mounting arrangements are available. Terminal arrangements nicely suited to 1/10 inch grid spacing.



• In one relay—the Type F—CLARE provides a precise component of unusual flexibility for long life operation under a wide variety of contact loads.

Tests have shown a performance of over 22,500,000 operations at 0.1 ampere, 115 volts a-c. Minimum contact life at 3 amperes is 100,000 operations. Contacts have carried 1 microampere, 1 millivolt for 700,000 operations with a failure resistance of 500 ohms, with no misses recorded.

This amazing low-level life is primarily a result of the use of gold plated contacts. These same contacts, however, will carry up to 3 amperes.

A special plug-in mounting arrangement that will stand extreme shock and vibration is now available.

The CLARE Type F Relay is hermetically sealed, operates perfectly in a wide range of temperatures, withstands heavy shock and vibration—is fast and more than moderately sensitive.

Send for Engineering Bulletin No. 124

Write or call C. P. Clare & Co., 3101 Pratt Blvd., Chicago 45, Illinois. In Canada: C. P. Clare Canada Ltd., 2700 Jane Street, Toronto 15. Cable Address: CLARELAY.

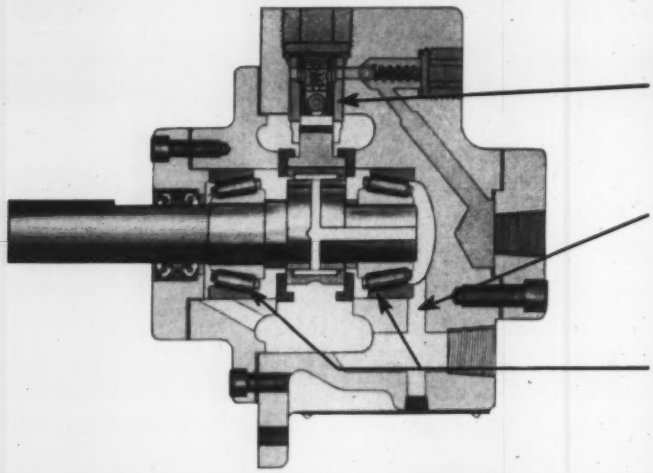
CLARE RELAYS

FIRST in the industrial field

Circle 432 on Page 19

AT PRESSURES TO 5,000 PSI . . .

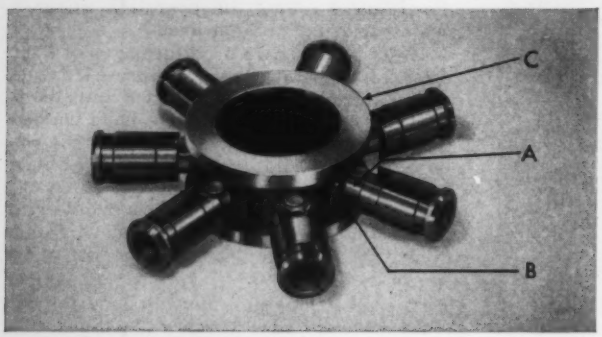
Only the AE Hydramite offers all these advantages



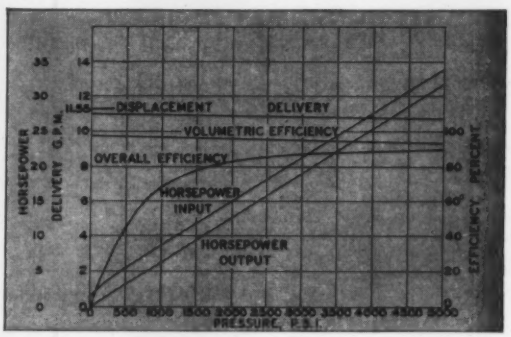
Liners and plungers are honed and individually mated for optimum fit.

Low friction losses. Pump operates with case flooded. Oil is ported to take advantage of natural pumping action of tapered bearings.

Heavy duty, high capacity tapered roller bearings absorb more punishment . . . handle maximum unbalanced loads . . . last longer.

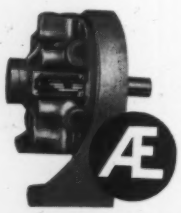


Positive pumping action. The Hydramite has no cam follower springs to fail. Plungers (A) are connected to curved slippers (B) which are held against the outer race of cam shaft needle bearing by two plunger return rings (C). As the shaft revolves, each plunger is pushed outward in succession and then pulled inward by the return rings.



High efficiency. With a Hydramite you get an overall efficiency of 85%. Its flat overall high efficiency curve has little variation between 1,500 and 5,000 psi. What's more with a Hydramite you get positive suction. There is no requirement for supercharging equipment which deducts from system efficiency.

To meet your specific requirements, Hydramite pumps can be supplied for constant displacement from 3 to 30 gpm at 5,000 psi and 70 to 85 gpm at 3,000 psi for hydraulic fluids with viscosities of 150 to 300 ssu at 100° F. In special applications they have handled viscosities as low as 40 and as high as 900 ssu at 100° F. Special materials and seals permit handling of missile fuels and special fluids at higher temperatures. Available in flange, foot or face mounted styles. Write or call American Engineering Company, Philadelphia 37, Pennsylvania. Phone: Cumberland 9-3800.



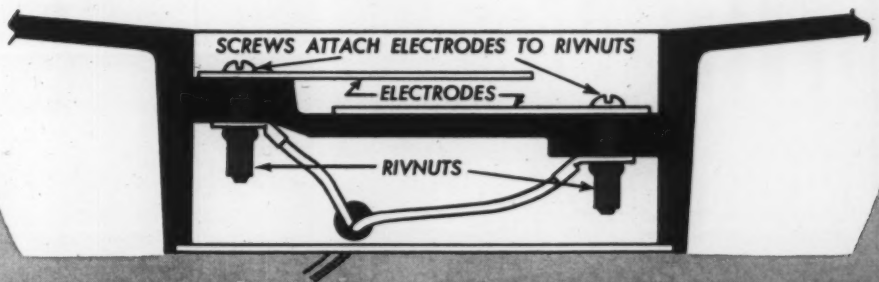
AMERICAN ENGINEERING COMPANY

Hele-Shaw Pumps, Lo-Hed Hoists, AE Marine Deck Auxiliaries, Vibra Grate, Perfect Spread and Taylor Stokers.

Circle 433 on Page 19

B.F.Goodrich

B. F. Goodrich RIVNUTS® simplify design, production of Hankscraft sterilizer



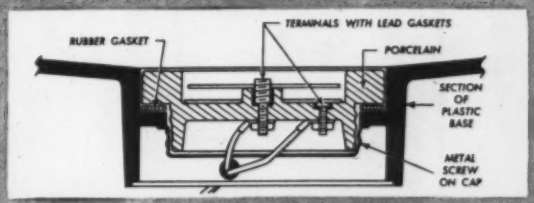
Here's why Hankscraft Company turned to B.F.Goodrich Rivnuts when they streamlined design, production and appearance of the Model 200A Baby Bottle Sterilizer.

Before Rivnuts, the electrodes and terminals were fastened to a large porcelain "dish" by screws and nuts. Four gaskets were required to prevent water leakage. A metal screw-on cap had to be fitted underneath the porcelain "dish". *(See small sketch)*

Rivnuts eliminate all these cumbersome pieces. Installed in the simplified plastic base, Rivnuts secure terminals, provide water-tight nut plates. Two screws attach electrodes — and the unit is complete.

You can get B.F.Goodrich Rivnuts in thread sizes 4-40 to ½"-13 with flat or countersunk heads. Rivnuts have hundreds of applications in appliances, electronic equipment, machinery and structures. Special types are available for aircraft and missiles.

Write now for free copy of the Rivnut Data Book. Better yet, send us a sketch of your toughest fastening problem. *B.F.Goodrich Aviation Products, a division of The B.F.Goodrich Company, Akron, Ohio.*



B.F.Goodrich ***aviation products***

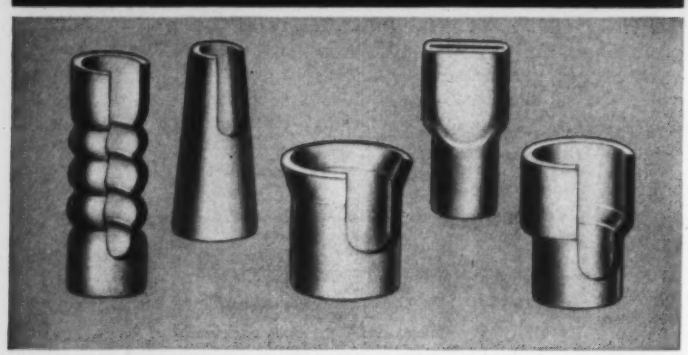
Circle 434 on Page 19

REPUBLIC ELECTRUNITE

world's widest range of

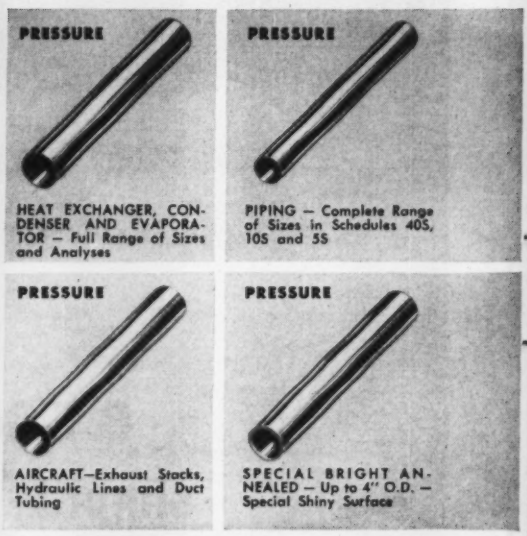
SPECIALTY WELDED TUBING

STAINLESS and CARBON

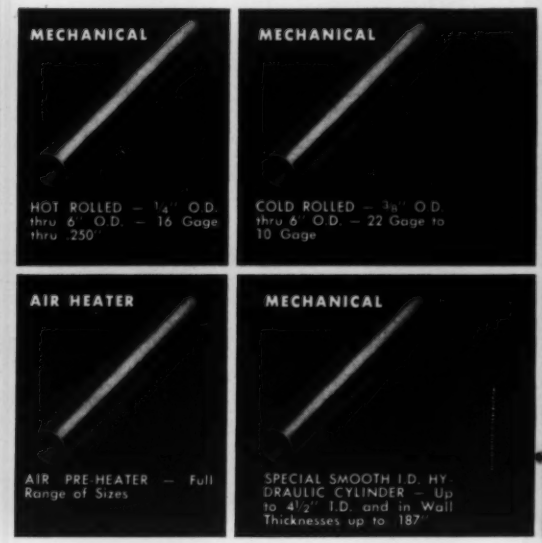


REPUBLIC ELECTRUNITE MECHANICAL TUBING is easily fabricated and formed by the user or through the fabricating and finishing facilities of Republic's Steel and Tubes Division. Round tubing can be furnished flanged, swaged, flattened, fluted, spun, configured, upset, rolled, and otherwise changed in cross-section to meet an endless variety of design requirements. Write for illustrated brochure.

STAINLESS


PRESSURE
HEAT EXCHANGER, CONDENSER AND EVAPORATOR — Full Range of Sizes and Analyses
PRESSURE
PIPING — Complete Range of Sizes in Schedules 40S, 10S and 5S
PRESSURE
AIRCRAFT—Exhaust Stacks, Hydraulic Lines and Duct Tubing
PRESSURE
SPECIAL BRIGHT ANNEALED — Up to 4" O.D. — Special Shiny Surface

CARBON


MECHANICAL
HOT ROLLED — 1/4" O.D. thru 6" O.D. — 16 Gage thru .250"
MECHANICAL
COLD ROLLED — 3/8" O.D. thru 6" O.D. — 22 Gage to 10 Gage
AIR HEATER
AIR PRE-HEATER — Full Range of Sizes
MECHANICAL
SPECIAL SMOOTH I.D. HYDRAULIC CYLINDER — Up to 4 1/2" I.D. and in Wall Thicknesses up to .187"

Republic ELECTRUNITE® offers you the world's widest range of stainless and carbon tubing. Carbon steel round tubing in sizes up to 6" O.D.—squares and rectangles in peripheries up to 20". Stainless steel tubing in sizes up to 5" O.D.—squares and rectangles in peripheries up to 16". And a complete range of stainless pipe sizes.

ELECTRUNITE is quality controlled from ore to finished product. Produced in Republic's own mills to rigid requirements.

Welded by the exclusive ELECTRUNITE process—a continuous electric-weld method that unites the wall under pressure without the addition of foreign or extra metal. Tests prove the weld is as strong or stronger than the original base metal.

Next time you need tubing, whatever the application or problem, call your Republic representative. Or, write direct.

STEEL TUBING AND PIPE

½" O.D. TO 40" O.D.

SANITARY — O.D. and I.D. Polished — For Dairy, Food and Fruit Juice Processing

HEAT RESISTANT — Special Analyses — 309, 309S, 310, 321, 330, 347 and 348

BEVERAGE — Cut Lengths or 50' Coils

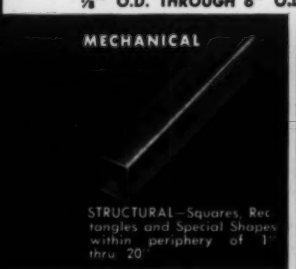
FULL FINISHED — Annealed and Tested for All Mechanical Uses — All 300 Series Analyses

ORNAMENTAL — Type 302 — Not Annealed — Not Pressure Tested

STAINLESS CLAD — Double Wall — Outside Stainless — Inside Carbon

STEEL TUBING

⅛" O.D. THROUGH 6" O.D.



STRUCTURAL—Squares, Rectangles and Special Shapes within periphery of 1" thru 20"

HEAT EXCHANGER AND CONDENSER — To A.S.T.M. — A-214 — To Customer's Special Specifications

BOILER TUBES—To A.S.T.M. A-178 and Government Specifications

HYDRAULIC LINE — ⅜" O.D. and Larger

REFRIGERATION—Complete Size Range

FABRICATION — All Types of Fabrication Available

SIZE—GAGE RANGE CHART ROUND TUBING

Outside Diameter of Tube	Wall Thickness (B. W. Gage)	
	Carbon Steels	Stainless Steels
	Mechanical Tubing	Mechanical Tubing
¼"	.....	16-25
⅜"	18-22	16-25
7/16"	16-22	16-25
½"	16-22	14-25
9/16"	14-22	14-25
⅝"	14-22	14-24
11/16"	14-22	14-24
¾"	9-22	13-24
13/16"	9-22	13-24
⅞"	9-22	12-23
15/16"	9-22	12-23
1"	6-22	11-23
1 1/16"	6-22	11-22
1 ⅛"	6-22	11-22
1 3/16"	6-22	11-22
1 ¼"	6-22	11-22
1 5/16"	6-22	11-20
1 ⅜"	6-22	11-20
1 7/16"	6-22	11-20
1 ½"	6-20	10-20
1 9/16"	6-20	10-20
1 ⅝"	6-20	10-20
1 11/16"	6-20	10-20
1 ¾"	6-20	10-20
1 ⅞"	6-20	10-20
2"	6-20	9-20
2 1/16"	6-20	.....
2 ⅛"	6-20	9-20
2 3/16"	6-20	.....
2 ¼"	5-20	9-20
2 ⅜"	5-18	8-20
2 ½"	5-18	8-20
2 9/16"	5-18	.....
2 ⅝"	5-18	8-20
2 ¾"	.250"-18	8-20
2 ⅞"	.250"-18	8-20
3"	.250"-18	8-20
3 ¼"	.250"-18	8-16
3 ½"	.250"-18	8-16
4"	.250"-16	8-16
4 ⅛"	14-16	.....
4 ½"	.250"-16	8-16
5"	.250"-16	8-16
5 ½"	.250"-16	.....
6"	.250"-16	.....

Above are common available sizes. Intermediate sizes also available. Tubes are manufactured by several processes in accordance with the size-gage ratio; therefore not all sizes and gages are readily available in all grades of product. Please contact your nearest Steel and Tubes Division Representative for delivery information on specific size, gage, and grade desired.

REPUBLIC STEEL

World's Widest Range of Standard Steels and Steel Products

REPUBLIC STEEL CORPORATION
STEEL AND TUBES DIVISION
DEPT. C-7682
217 EAST 131ST STREET • CLEVELAND 8, OHIO

Please send additional information on the following:

- ☐ Stainless Steel Tubing . . . Type_____
- ☐ Stainless Steel Pipe . . . . Type_____
- ☐ Carbon Steel Tubing . . . . Type_____
- ☐ Please have a Republic Engineer call.

Name_____ Title_____

Firm_____

Address_____

City_____ Zone____ State_____

Circle 435 on Page 19

Wanted: Engineers

with an interest in writing

Like to break into an interesting field where you'll make good use of your engineering talents — yet have a chance to develop new skills?

We're looking for several men with engineering experience and a yearning to write or edit. As an editor on MACHINE DESIGN, you would broaden your engineering background in a job that provides stimulating contact with people in many engineering areas.

You don't have to have actual writing or editing job experience, although we expect definite ability in handling the English language. An ME or EE degree plus several years of design-engineering experience would be ideal, but we'll be happy to consider equivalent qualifications. Age: 25 to 35.

If you've worked in a design-engineering specialty area, we'd like to hear about it. We're interested in any job experience or training in:

- Mechanical drives, controls, systems
- Mechanical components, assemblies
- Electrical or electronic drives, controls, systems
- Hydraulic or pneumatic systems, drives, controls
- Materials and finishes selection or specification
- Design for manufacture or production design

Our headquarters are in Cleveland. There is opportunity for travel to engineering meetings, expositions, and manufacturing companies. Salary will depend on your background and experience.

If you are interested, send a resume of your engineering background, and any evidence you may have of writing ability (we'll return this if you wish) to: Editor, MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio.

MACHINE DESIGN

Circle 437 on Page 19→

WAGNER Integral-Type Gearmotors

Wagner Integral-Type Gearmotor with TEFC motor. Standard or explosion-proof.

Wagner Integral-Type Gearmotor with open protected motor.

For the Power you want - At the Speed you need !

Wherever you need "slower than motor speeds" you can get positive speed reduction with plenty of power by using Wagner Gearmotors.

This extension to the Wagner line provides compact motorized drives, with both motor and gear housing of corrosion-resistant cast iron. Available with the latest NEMA Frame open protected or totally enclosed fan-cooled motors, they combine Wagner motor dependability with rugged, simplified gear units to give you speed reduction equipment designed for greater capacity and longer life in ordinary up to rough service.

Wagner Gearmotors offer a wide variety of sizes in single, double, triple or quadruple reductions—horizontal or vertical foot or flange mountings—speeds from 7½ to 780 RPM. Write for Bulletin MU-227.

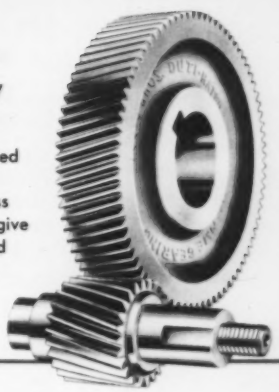
Whether you specify or apply power transmission equipment, your nearby Wagner Sales Engineer will be glad to help you select the right drive for your applications. There are Wagner Branches in 32 principal cities.

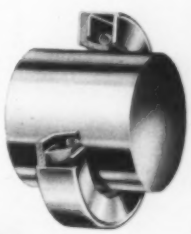
Wagner Electric Corporation

6400 PLYMOUTH AVENUE, ST. LOUIS 14, MISSOURI

Heat treated high capacity helical gears

Gears are hardened after cutting, for maximum hardness and accuracy, to give extra capacity and longer wear life.

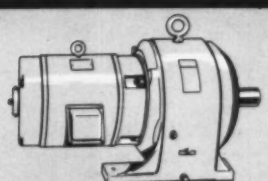




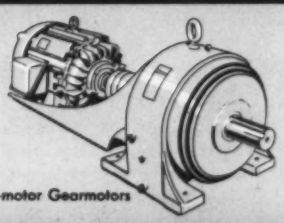
Positive Oil Seals

Improved lip type seals are used on horizontal shafts. On vertical output shafts, double mechanical seal with slinger and drain-off gives positive protection against leakage.

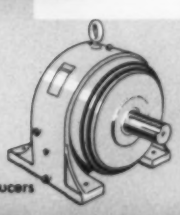
WAGNER SPEED REDUCTION EQUIPMENT



Integral-Type Gearmotors



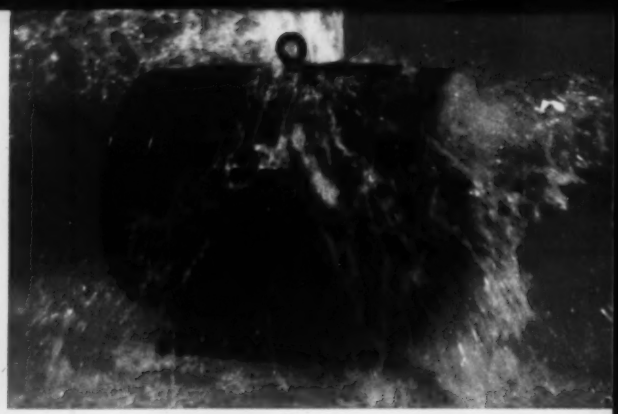
All-motor Gearmotors



Speed Reducers

Shaft-mounted Speed Reducers

DOUBLY PROTECTED. Air intakes and outlets protect against falling or splashing liquids. Cast iron frames protect against rough handling and corrosion.



TYPE DP · Doubly Protected against corrosion · against falling or splashing liquids

These motors give the double protection of corrosion-resistant cast iron frames and dripproof enclosures that are so well designed that they can be used in many applications that formerly required splashproof motors. Available with ball bearings, or with high load carrying capacity sleeve bearings for extra quiet operation. Write for Bulletin MU-223.

1 TO 125 HORSEPOWER – 1750 RPM – 40° C – NEMA FRAMES 182 THROUGH 445U

You get less downtime, lower upkeep, with WAGNER PROTECTED-TYPE MOTORS

If you need motors that will keep production rates up . . . that will give you the continuity of service you want . . . that will operate with complete dependability under the most severe conditions in their specific applications—use Wagner Protected-Type Motors. These motors pack extra power into little space, are light in weight, and are easy to maintain.

Let your Wagner Sales Engineer show you how these protected motors can bring you savings in initial motor costs, maintenance costs, and in continuity of operation.

Wagner Electric Corporation
6400 PLYMOUTH AVENUE, ST. LOUIS 14, MO., U. S. A.

WM59-10

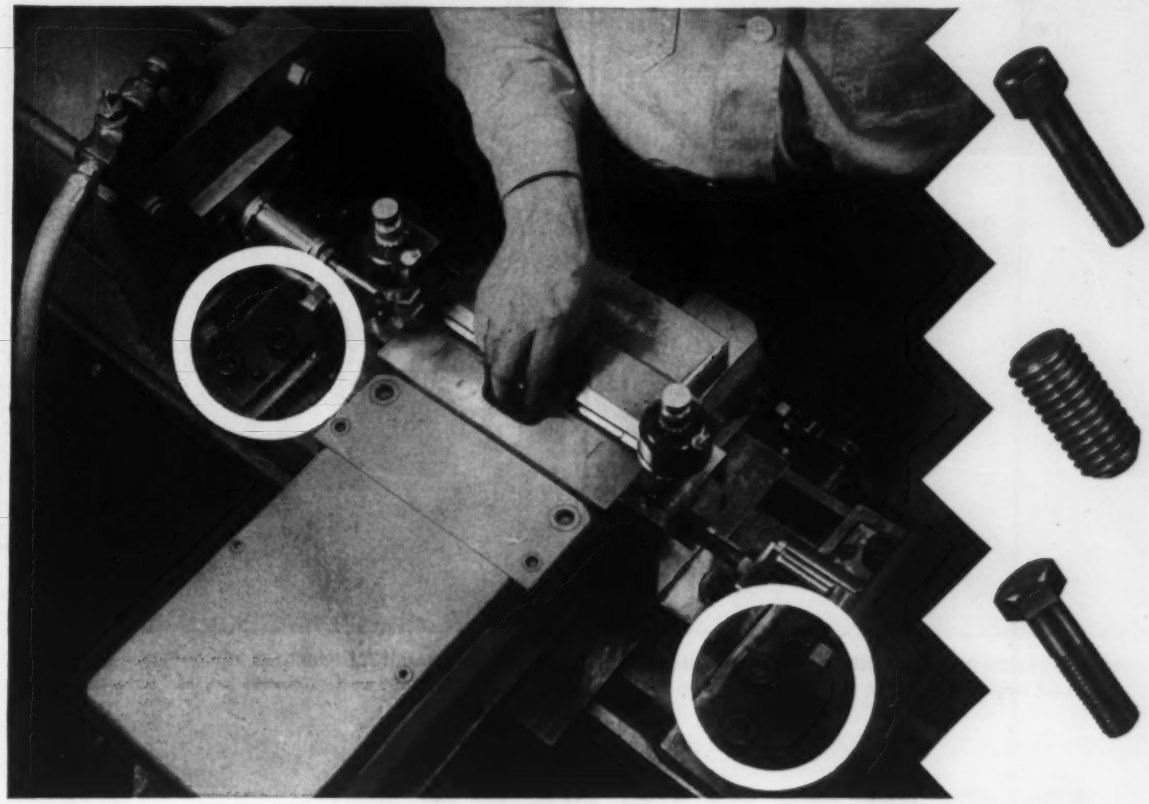
1 TO 100 HORSEPOWER – 4 POLE – 60 CYCLE – NEMA FRAMES 182 THROUGH 445U

TYPE EP · Extra Protected against corrosive or abrasive elements

Wagner Type EP Motors are totally-enclosed, fan-cooled—for complete protection against dust, abrasives, fumes, steel chips or filings. Type JP is explosion proof as well—designed and approved for use in explosive atmospheres. Cast iron frames protect against corrosion and ribs on the frames add mechanical strength and increase the surface cooling area. Effective cooling system adds to motor life. Write for Bulletin MU-224.

SECURELY SEALED FOR LOW MAINTENANCE. Both ends of these motors have running shaft seals to keep the heavy duty bearings clean. Bearing housings are effectively sealed to prevent escape of grease. Openings are provided to permit relubrication that adds years to motor life under severe conditions.

IT PAYS TO STANDARDIZE ON **STANSCREW**



A 20-ton impact load . . . 14,400 times a day! Stanscrew Fasteners solve the problem

Fastening the air cylinders on this tube former is a real problem. Each of these 8" bore cylinders delivers a thrust of over 20 tons every time the machine is operated. And since this happens 14,400 times in a normal working day, ordinary fasteners would soon fail under these repeated shock loads. Furthermore, not even the slightest misalignment can be tolerated in this machine.

The Stanscrew fastener specialist was able to quickly answer this demanding problem. His solution was Stanscrew Socket Head Cap Screws, tightened to within 80% of yield strength so they remained in tension. These fasteners, so applied, deliver a clamping force that eliminates the shock feature of this extremely high loading . . . and provides a 100% factor of safety.

Tough assignments like this are everyday jobs for your Stanscrew fastener specialist. Immediately on call, through your Stanscrew distributor, he can bring to your problem years of specialized experience. And, back of him, is an outstanding staff of engineers who have been solving the fastener problems of American industry since 1872.

Stanscrew's complete line of more than 4,000 different types and sizes will provide economical answers to your fastener requirements. All 4,000 items are always in stock, quickly available.

Call your Stanscrew distributor today for solutions to your fastener problems. He will arrange a prompt meeting with the Stanscrew fastener specialist . . . who can often suggest ways to save you money by substituting standard fasteners for costly specials.

STANSCREW FASTENERS

CHICAGO | THE CHICAGO SCREW COMPANY, BELLWOOD, ILLINOIS
HMS | HARTFORD MACHINE SCREW COMPANY, HARTFORD, CONNECTICUT
WESTERN | THE WESTERN AUTOMATIC MACHINE SCREW COMPANY, ELYRIA, OHIO

STANDARD SCREW COMPANY 2701 Washington Boulevard, Bellwood, Illinois

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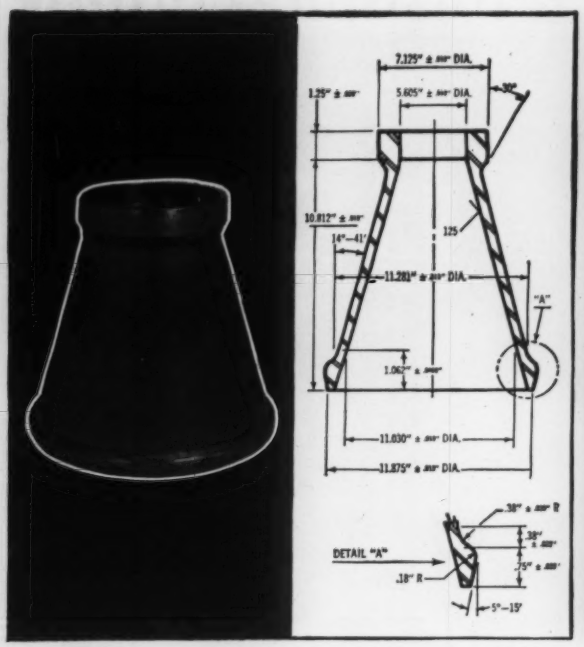
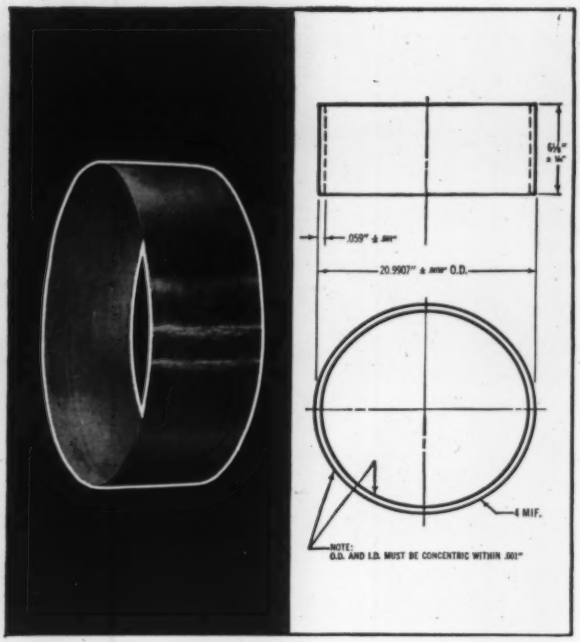


STRAIGHT SIDE ROCKET CONE—Spun with tapered wall from 1020 steel blank: 18" diameter, 1" thick. Inside surface 125 MIF.



STRAIGHT WALL TUBE PRINTING BAND—Spun from ⅛" thick aluminum to .060" wall thickness, outside surface machine finished to 4MIF.

ROTOFORMS open new

ROTOFORMING reduces cost of unusual metal shapes—saves metal, eliminates machining and surface finishing

The design possibilities for hollow metal shapes are now unlimited. The most unusual metal custom parts can be practically and economically produced by ROTOFORMING.

This revolutionary new metal forming service now being offered by COMMERCIAL SHEARING & STAMPING displaces metal in a blank or preform. Rollers contacting the outside surface of the metal form it by high pressure as it rotates around a mandrel. The shape of the mandrel itself, at all times, controls the inside contour and size of the part.

WHAT SHAPES ARE POSSIBLE? Basically, ROTOFORMS can be grouped into four main categories: Straight-Side Cones, Straight-Wall Tubes, Curvilinear-Wall Shapes, and Elliptical or Hemispherical Shapes. Pictured above are representative ROTOFORMS already produced by COMMERCIAL. Principal dimensions are included.

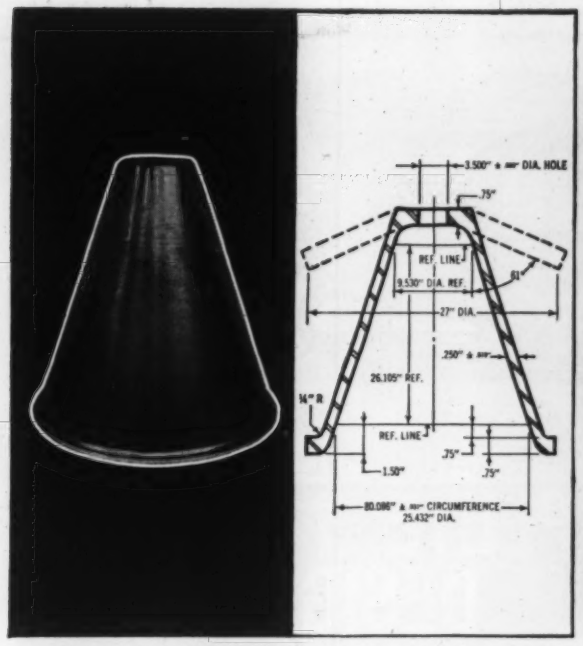
WHAT ABOUT SIZE AND WALL THICKNESS? The range of sizes for ROTOFORMS covers maximum diameters up to 42" down to a minimum tube I.D. of 2¼". Tube length can go as high as 100".

Steel blanks up to ¾" thick can be successfully handled by ROTOFORMING where conical shapes are involved. And when it comes to forming straight-wall tubes the wall thickness of steel blanks can even go up to ⅝". When forming metals more ductile than steel it is possible to work blanks with even greater wall thicknesses than those above.

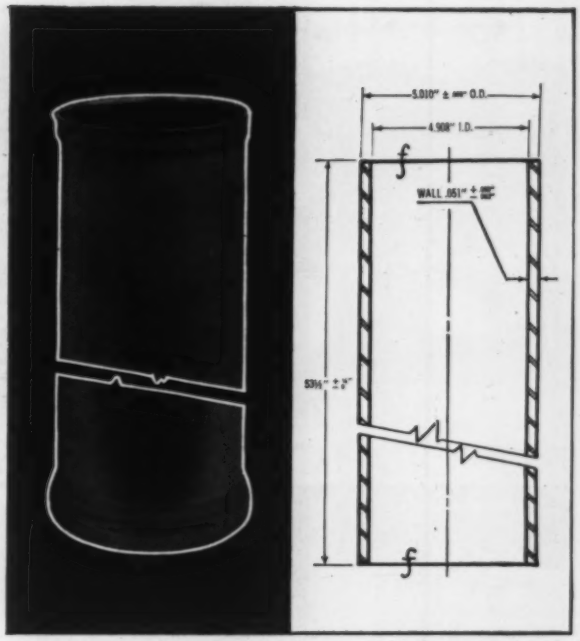
With ROTOFORMS wall thicknesses—both constant and variable—are feasible. Walls referenced to C/L can be straight, curved, or tapered. And ROTOFORMS have been successfully produced with a finished wall thickness no greater than 1/32".

WHAT METALS CAN BE ROTOFORMED? A wide variety of carbon steels, stainless and special alloy steels, as well as aluminum, nickel, copper, molybdenum, magnesium and titanium alloys can be successfully ROTOFORMED. Even metal alloys such as 4130 steel, 1100-0 aluminum, and hard to machine Hastelloy, can and are being used in the regular production of ROTOFORMS.

WHAT HAPPENS TO THE METAL? The plastic deformation which metals undergo in the ROTOFORMING process elongates their grain structure and sub-



STRAIGHT SIDE MISSILE EXIT CONE—Spun with constant wall thickness from press pre-formed 1040 steel blank: 29" diameter, ¾" thick.



STRAIGHT WALL ROCKET TUBE—Spun from 4135 steel tubing (wall thickness ½") reduced to finished wall .051".

horizons for metal shape design!

stantially increases their strength. Tensile increases 1½ to 2 times, yield point is raised in even higher proportion, and fatigue strength is substantially improved. And ROTOFORMED parts can be heat treated to increase their ductility.

Because of the plastic deformation of metal, involved weld joints become unnoticeable when ROTOFORMED. And there are no hidden metal flaws in ROTOFORMS. Any metal inclusions or flaws in the parent metal are quickly uncovered during the ROTOFORMING process—appear as ruptures when pressure spinning rolls reposition the metal by physical displacement. Only 100% sound metal will produce successful ROTOFORMS.

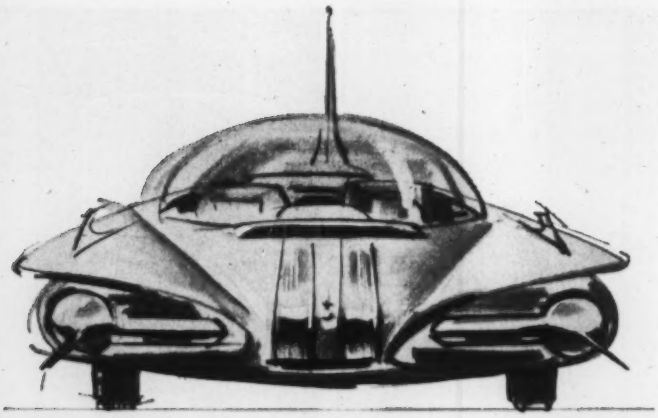
WHAT ABOUT TOLERANCES AND FINISHES? Extremely close tolerances and tolerances commonly associated with fine machining are routine in the production of ROTOFORMS. It is not uncommon for ROTOFORMED parts taken from the machine as is to have inside diameters held to tolerances of +.000" −.003", +.005" −.000", and +.005" −.005".

Inside areas of ROTOFORMS finish to a glass-like surface—30 to 60 micro inch finishes being well within standard production practice. While outside surfaces finish to about 125 micro inch.

Because dimensional tolerances and inside surface finish have a direct relation to the variation and finish of blank from which the ROTOFORM is produced, when necessary the tolerances of a blank can be reduced and its finish improved beforehand in order to provide closer tolerances and a better inside finish in the actual ROTOFORM. In addition, the outside surfaces of ROTOFORMS can be brought to smoother finish by grinding, polishing or fine machining.

AN INVITATION FROM COMMERCIAL! This new metal forming process could be the practical and economical answer to your particular component problem. You can find out very quickly. Just a blueprint, sketch or prototype of your part in the hands of our engineers will bring you the complete cost-saving story—and at no obligation. Address inquiries to Commercial Shearing & Stamping Co., Dept. S-18, Youngstown 1, Ohio.

COMMERCIAL
shearing & stamping



PUROLATOR'S DRY TYPE AIR FILTERS GIVE COMPLETE DESIGN FREEDOM

With Purolator's new dry type air filters, there's no need to keep a constant, level bearing . . . to set the air cleaner on top of the block. There is no oil to spill, no level to be maintained. This makes it possible to place the filter anywhere at all . . . under the engine, on the side . . . wherever it allows the most design freedom.

Of course, the big advantage in dry type filtration is the optimum efficiency it affords. The Micronic dry type element is just as effective at low speeds as at high speeds. And instead of becoming less efficient with use, its already outstanding 99% efficiency *increases* to 99.7%.

Design your cars the way you want them . . . then call on Purolator to design and produce the air filter to fit your design.

Filtration For Every Known Fluid **PUROLATOR**

PRODUCTS, INC.

RAHWAY, NEW JERSEY AND TORONTO, ONTARIO, CANADA

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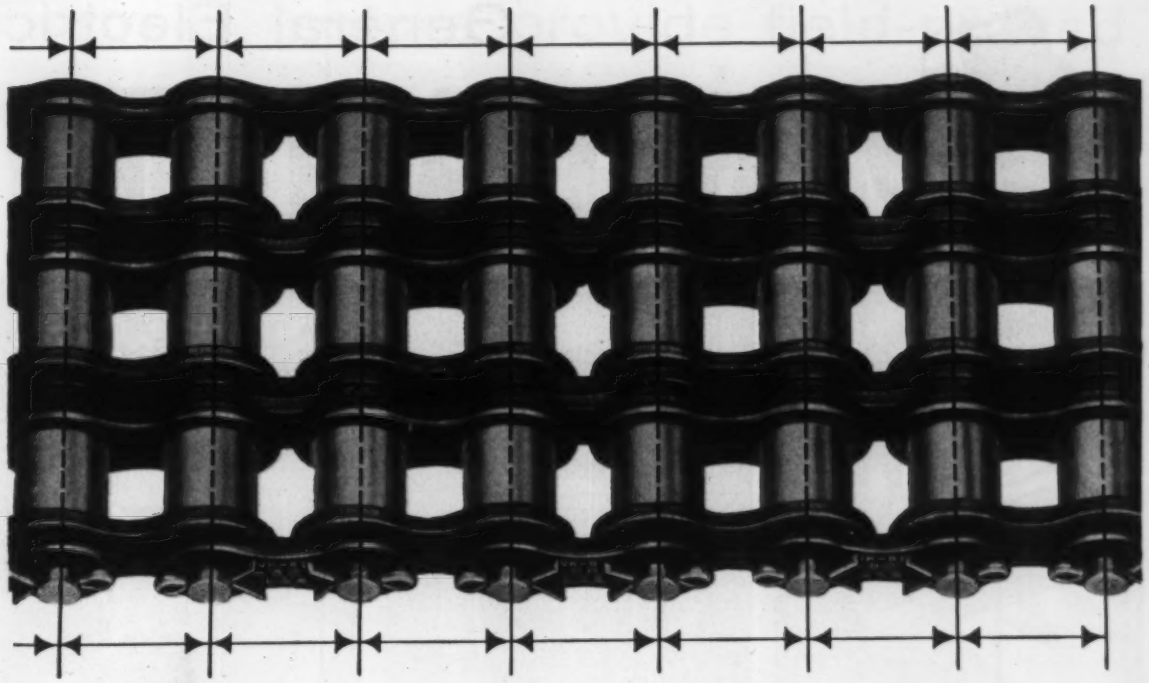


Equal length... equal strength

How pre-stressing ensures uniform load distribution of multiple-width LINK-BELT roller chain

Pre-stressing is one of the reasons why Link-Belt multiple-width precision steel roller chains easily handle the grueling loads common on today's drives. It seats and cold works the chain joint parts, assuring equal load distribution across the chain, minimum initial elongation, increased fatigue life.

Pre-stressing is just one of many "extras" that contribute to the *greater dynamic strength* of Link-Belt roller chain. Others include: close heat-treat control, lock-type bushings, shot-peened rollers, pitch-hole preparation. For details see Book 2657.

PRE-STRESSING MACHINE provides the pull that "sets" the parts of Link-Belt multiple-width roller chain. Besides assuring uniform load distribution, pre-stressing eliminates application difficulties on fixed center drives because the chain leaves the factory at precise operational length.

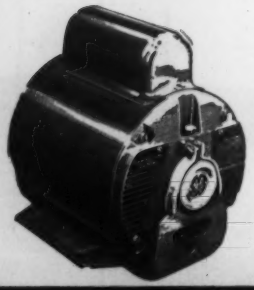
LINK-BELT

ROLLER CHAINS AND SPROCKETS

BOOK 2657 has 154 pages of roller chain data. Contact your nearest Link-Belt office. (See CHAINS in the yellow pages of your classified phone directory.)

15,078

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office, New York 7; Australia, Marrickville (Sydney); Brazil, Sao Paulo; Canada, Scarboro (Toronto 13); South Africa, Springs. Representatives Throughout the World.

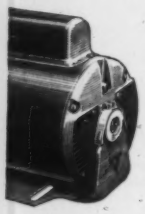


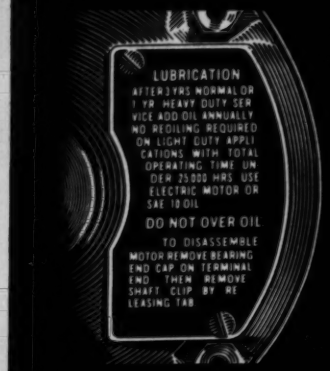
General Electric RELIABILITY

RUST-RESISTANT SHAFT

New protective shaft finish resists rusting, looks better, lasts longer

General Electric Form G motors feature a special gun-metal-like treatment of the shaft which resists rust and corrosion. Fans, pulleys, and couplings are easy to remove. Even endshield latches and hardware now are bright plated to last longer, look better. G-E Form G motors assure you the extra life and easy maintenance your customers want!

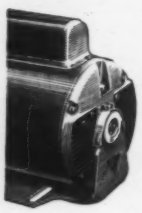



LUBRICATION
AFTER 3 YRS NORMAL OR 1 YR HEAVY DUTY SERVICE ADD OIL ANNUALLY. NO REOILING REQUIRED ON LIGHT DUTY APPLICATIONS WITH TOTAL OPERATING TIME UNDER 25,000 HRS USE ELECTRIC MOTOR OR SAE 10 OIL
DO NOT OVER OIL
TO DISASSEMBLE MOTOR REMOVE BEARING END CAP ON TERMINAL END. THEN REMOVE SHAFT CLIP BY RELEASING TAB

LONG-LIFE LUBRICATION

Large oil supply and superb retention system cut maintenance

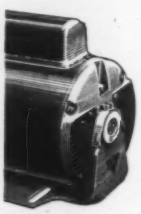
Form G motors require little reoiling and on some applications no reoiling at all. This results from a 50% larger oil reservoir plus a highly efficient method of retaining oil. (On G-E ball bearing motors, a special long-life grease gives up to 10 years' service without relubrication.) Another good reason for you to choose General Electric Form G's!



ACCURATE ALIGNMENT

Sturdy, disk-type endshields assure accurate bearing alignment

General Electric Form G's feature disk-type endshields, heavily ribbed for high rigidity and long life. The rabbet and bearing are placed in the same plane and machined simultaneously to provide inherent bearing alignment. Form G endshields won't warp! Accurate, permanent alignment means longer bearing life and dependable motor operation.

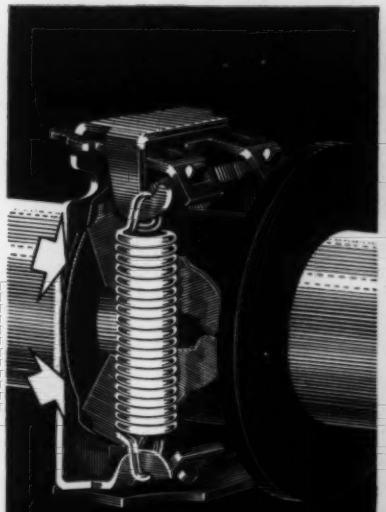


GENERAL ELECTRIC GENERAL ELECTRIC GENERAL ELECTRIC

JUST ASK YOUR GENERAL ELECTRIC SALES ENGINEER

Form G motors provide field-proved

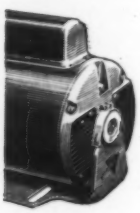
YOU CAN COUNT ON



QUIET, SURE SWITCH

Dependable centrifugal switch gives quiet, positive snap-action

The centrifugal switch on Form G's is designed to stand up to heaviest demands (3,500,000 test operations). Add to this a switch that's quieter than ever. A carefully designed composition washer greatly reduces start-stop click without sacrificing positive snap action. Here's another Form G difference that means more satisfied customers for you!

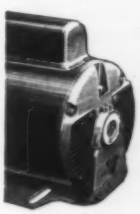


GENERAL ELECTRIC

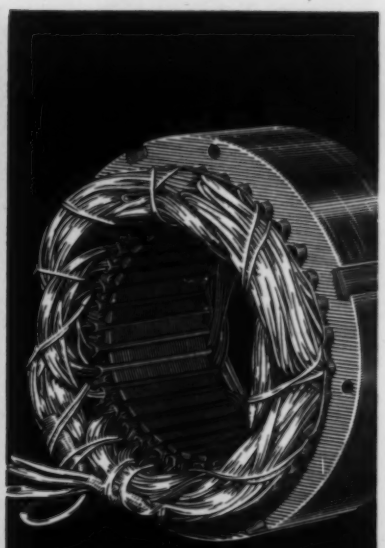
THRUST PROTECTION

Washer assembly absorbs thrust from any direction; contributes to longer life

A specially-designed three-piece thrust washer assembly, keyed to rotate with the shaft, withstands normal thrust from any direction, regardless of motor angle. It also acts as an oil seal to help provide positive oil retention, contributing to longer lubrication life and reduced maintenance. If you're looking for a motor that's built to last, try Form G!



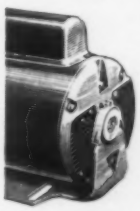
GENERAL ELECTRIC



LONG-LIFE STATOR

Heavy-duty bonding dip and stator clamps provide rigid, uniform assembly

Along with the Mylar*-Formex** insulation system pioneered by G.E., you now get a new bonding treatment on Form G motor stators. It affords added protection against stress. Stator cores are now specially clamped for highly accurate alignment. These new features result in extra rigidity, more uniform quality. Here's longer motor life!



*Reg. trade-mark, DuPont Co.
**Reg. trade-mark, G.E. Co.

702-91

GENERAL ELECTRIC

ABOUT THE NEW FORM G "EXTRA VALUE" FEATURES

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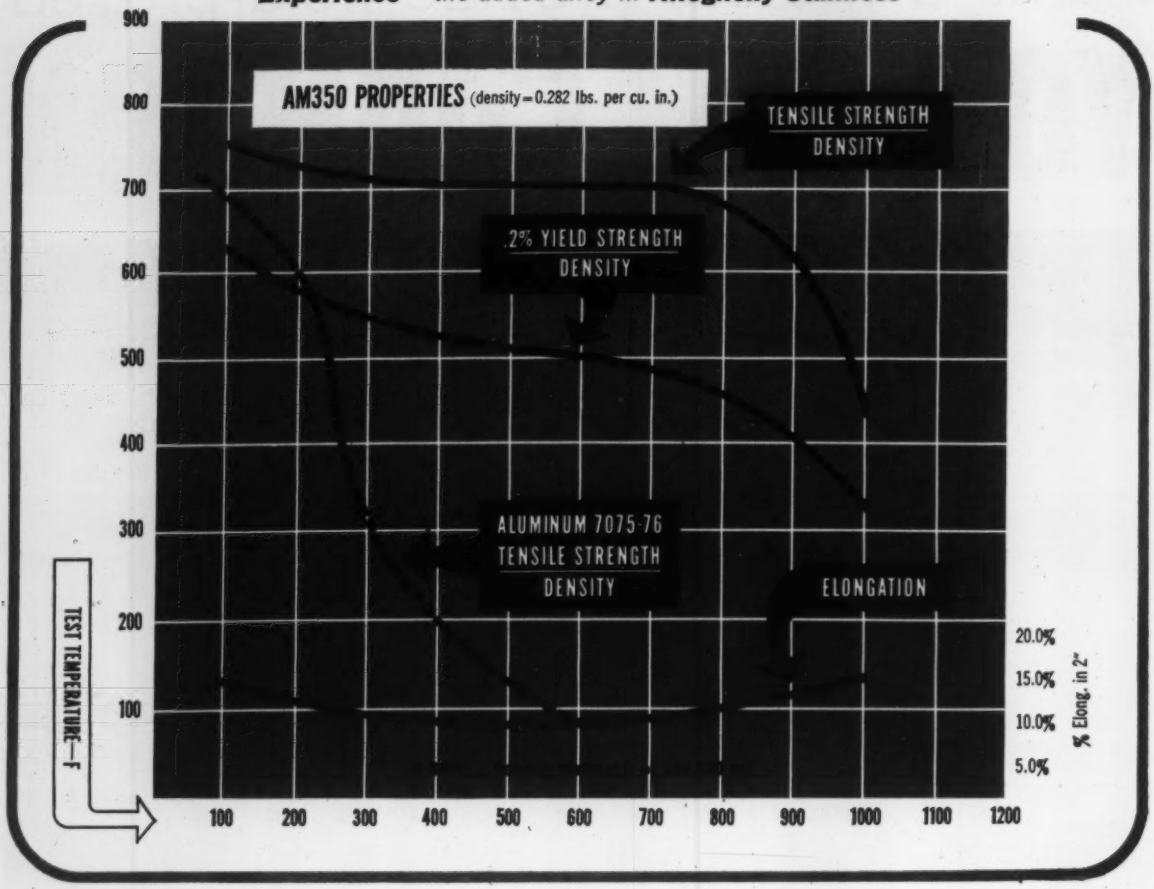
Experience *— the added alloy in* ***Allegheny Stainless***



Two for the space age—AL's AM-350 and AM-355 precipitation hardening steels

A unique combination of highly desirable properties describes Allegheny Stainless AM-350 and AM-355 Steels. They combine high strength at both room and elevated temperatures, excellent corrosion resistance, ease of fabrication, low temperature heat treatment, good resistance to stress corrosion.

They are proving the answer to many space age problems. Airframe and other structural parts, pressure tanks, power plant components, high pressure ducting, etc. are all natural missile and supersonic aircraft applications for AM-350 and AM-355.

AVAILABILITY: AM-350, introduced several years ago, is available commercially in sheet, strip, foil, small bars and wire. AM-355, best suited for heavier sections, is available commercially in forgings, forging billets, plates, bars and wire.

CORROSION RESISTANCE: Compared to the more familiar stainless grades, AM-350 and AM-355 resist corrosion and oxidation better than the hardenable grades (chromium martensitic) and only slightly less than the 18 and 8's. They resist stress corrosion at much higher strength levels than do martensitic stainless grades.

SIMPLE HEAT TREATMENT: High strength is developed by two methods. Both minimize oxidation and distortion problems. The usual is the Allegheny Ludlum-developed sub-zero cooling and tempering (SCT): minus 100F for 3 hrs plus 3 hrs at 850F. Alternate method is Double Aged (DA): 2 hrs at 1375F plus 2 hrs at 850F.

EASY FABRICATION: AM-350 and AM-355 can be spun, drawn, formed, machined and welded using normal stainless procedures. In the hardened conditions, some forming may be done . . . 180 degree bend over a 3T radius pin. Also AM-350 can be dimpled in the SCT condition to insure accurate fit-up.

For further information, see your A-L sales engineer or write for the booklet "Engineering Properties, AM-350 and AM-355." *Allegheny Ludlum Steel Corporation, Oliver Building, Pittsburgh 22, Pa. — Dept. MD - 161*

WSW 7816

ALLEGHENY LUDLUM

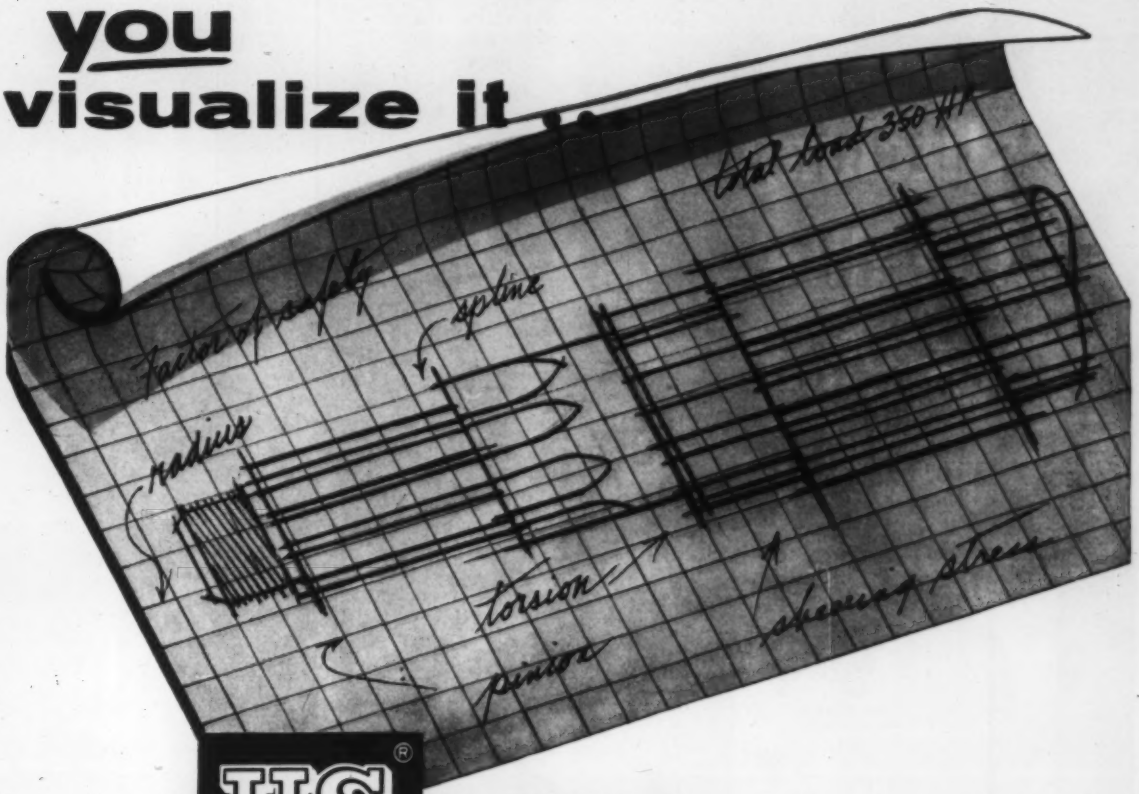
Export distribution: AIRCO INTERNATIONAL

EVERY FORM OF STAINLESS . . . EVERY HELP IN USING IT

AL

Circle 444 on Page 19

you visualize it



US® AXLE will customize it!

Let U. S. AXLE make your AXLE SHAFTS . . . for extra resistance to strain, stress and wear . . . whether you're visualizing a new machine design or simply building "more of the same."

Precision-engineered to your specifications (or including our help), finest alloy steels are heat treated, then shot-peened for 5 times greater toughness, longer dependability, lower machine-operating costs. They're backed by nearly 40 years of success with custom and replacement axle shafts for every automotive and industrial use . . . for America's top names.

Whatever your need . . . rely on U.S. AXLE SHAFTS to do their job longer . . . make *your* equipment better!

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THE U. S. AXLE COMPANY
Pottstown, Pennsylvania

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stitching together a giant radome

Radome designed and built by Long Sault Woodcraft Limited, St. Andrews East, Quebec, for the United States Air Force RADC.

Looking upward from the inside of the world's largest stressed skin sandwich radome built of translucent fiberglass panels, securely joined by hundreds of DUAL-LOCK fasteners.

Radar antennae along the upper perimeter of North America's defense system are enclosed by protective domes which stop ice, snow, and gales up to 150 mph.

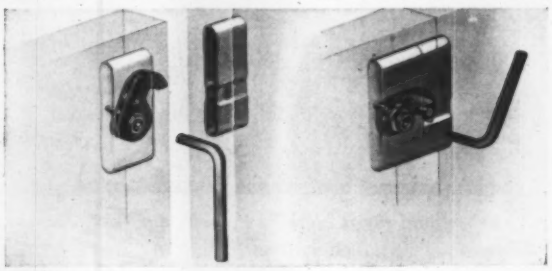
This precisely engineered pattern of fiberglass panels is erected quickly and surely, under the most adverse field conditions, using recessed Simmons DUAL-LOCK fasteners.

DUAL-LOCK is ideally adapted to panel fastening for military shelters, demountable shipping containers, aircraft cowlings and guided missiles.

Features:

- High load characteristics. The standard No. 1 DUAL-LOCK withstands 2500-lb. tension, and with modifications, tension loads of 7000 lbs. and over.
- Double-acting take-up provides great closing pressure, with minimum pressure on operating tool.
- Positive-locking. Trigger action insures fully open and fully closed positions.
- Vibration-proof and impact-proof. Will not accidentally unlock or loosen.

Write for catalog #1257. Complete specifications, drawings, details of DUAL-LOCK and other Simmons Fasteners with unlimited money-saving applications.



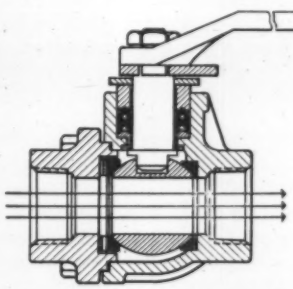
SIMMONS FASTENER CORPORATION

1756 North Broadway, Albany 1, New York *See our catalog in Sweet's Product Design File*

QUICK-LOCK • SPRING-LOCK • DUAL-LOCK • ROTO-LOCK • LINK-LOCK • HINGE-LOCK

Today's most streamlined valve!

The Rockwood Ball Valve ...only valve with full, round flow



No tapers . . . No obstructions!

You can practically forget about turbulence, friction loss, and plugging-up when you install a Rockwood Ball Valve. In "open" position, it offers little more resistance to flow than a cross-section of the pipe in which it is installed!

What's more, positive-seal design assures leakproof service over a wide range of pressures, temperatures, viscosities, particle sizes, etc. Ball *is not fastened* to the shaft . . . it literally floats, to assure best alignment with seat. At low pressures, a spring behind the ball positions it snugly against a resilient synthetic rubber seat. Increased pressure merely assists the action . . . the higher the pressure, the tighter the seal. In addition, ball's wiping action keeps seat free of foreign matter, a common cause of leaks in many ordinary valves.

The Type 316 Stainless Steel Ball Valve shown here is specifically designed for chemical service with adjustable chevron teflon stem seals, 316 stainless steel ball, spring, and handleshaft. For temperatures from −100°F to +400°F. Rating: 600 psi — W.O.G. Sizes ⅜″ thru 2″. Listed by Underwriters' Laboratories, Inc. For details on the line of Rockwood Ball Valves, send coupon.

ROCKWOOD BALL VALVES

FULL, ROUND FLOW

Distributors in all principal industrial areas

ROCKWOOD SPRINKLER COMPANY
1110 Harlow Street
Worcester 5, Mass.

Please send me new Catalog 59 on Rockwood Ball Valves.

Name.....

Title.....

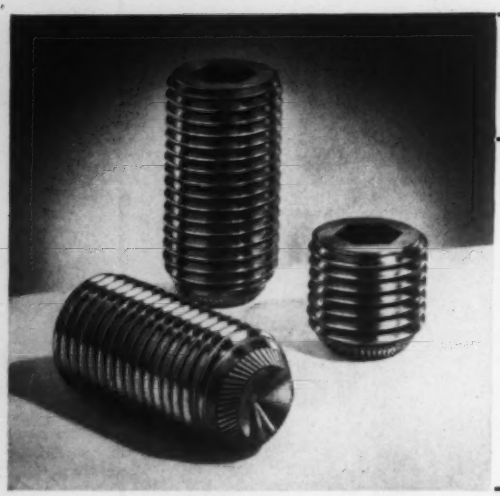
Company.....

Street.....

City.....*Zone*.....*State*.....

Circle 447 on Page 19

SPS RELIABILITY / *A dynamic standard of predictable performance*



RECOMMENDED SOCKET SET SCREW TIGHTENING TORQUES
(in.-lb.)

Screw Size	Unbrako	Set Screw B	Set Screw C	Minimum Differential %
#4	5	3.9	3.5	28
#5	9	7.8	7.4	15
#6	9	7.8	7.4	15
#8	20	14.7	14.5	36
#10	33	26.5	25	25
¼	87	62	60	40
5/16	165	122	125	32
⅜	290	198	225	29
7/16	430	309	350	23
½	620	460	500	24
5/8	1225	1106	1060	11
¾	2125	1540	1800	18
⅞	5000	3660	4600	9
1	7000	5025	6500	8

High torque UNBRAKO socket sets are available as follows: Sizes, #0 through 1 in.; materials, alloy steel and 18-8 stainless steel; Types, plain cup point (microsizes and stainless)—self-locking with knurled cup point (#4 through 1 in.)—self-locking with Nylok (plain cup point).

High Torque UNBRAKO socket set screws have up to 40% more holding power

Holding power—a vital factor in the selection and application of a set screw—is the result of the seating force developed by tightening the screw. Invariably the tighter a screw is wrenched into place, the greater will be the holding power. Recommended seating torques for High Torque UNBRAKO socket set screws are up to 40% higher than those for ordinary socket set screws. And the cup point, knurled counterclockwise, resists their backing out under vibration.

In addition to greater holding power, dimensional accuracy of length and OD, with consistent physical and mechanical properties from lot to lot, makes high torque UNBRAKO socket screws ideal for automation. Major diameters are held strictly to Class 3A thread tolerance to permit automatic feeding without jam-up. Socket depth and size are highly uniform to permit the driver to engage the socket in a split second and drive the screw home with speed and precision. Threads are fully formed to Class 3A fit to make the whole screw stronger and provide accurate mating. Heat treatment, in atmosphere controlled furnaces, prevents decarburization and provides hardness and strength for long wear.

High torque UNBRAKO socket set screws are stocked by authorized SPS industrial distributors. Ask the one nearest you for complete details. Or write SPS—manufacturer of precision threaded industrial fasteners and allied products in many metals, including titanium. Unbrako Socket Screw Division, STANDARD PRESSED STEEL CO., Jenkintown 18, Pa.

SPS **Jenkintown • Pennsylvania**

Standard Pressed Steel Co. • The Cleveland Cap Screw Co. • Columbia Steel Equipment Co. • National Machine Products Co. • Nutt-Shel Co. • SPS Western • Standco Canada Ltd. • Unbrako Socket Screw Co., Ltd.

Circle 448 on Page 19

the most important advance in couplings since Sier-Bath's flangeless design!

new

nyflex

Flexible Gear Couplings WITH NYLON SLEEVES

- No lubrication required
- Takes more misalignment than standard gear couplings
- Top performance in horizontal or vertical positions
- Weighs only 3½ pounds
- Low in price
- Speeds to 5000 rpm
- 1⅜" max. shaft capacity

ONLY 5 PARTS

Assembles, disassembles in seconds, no special tools needed!

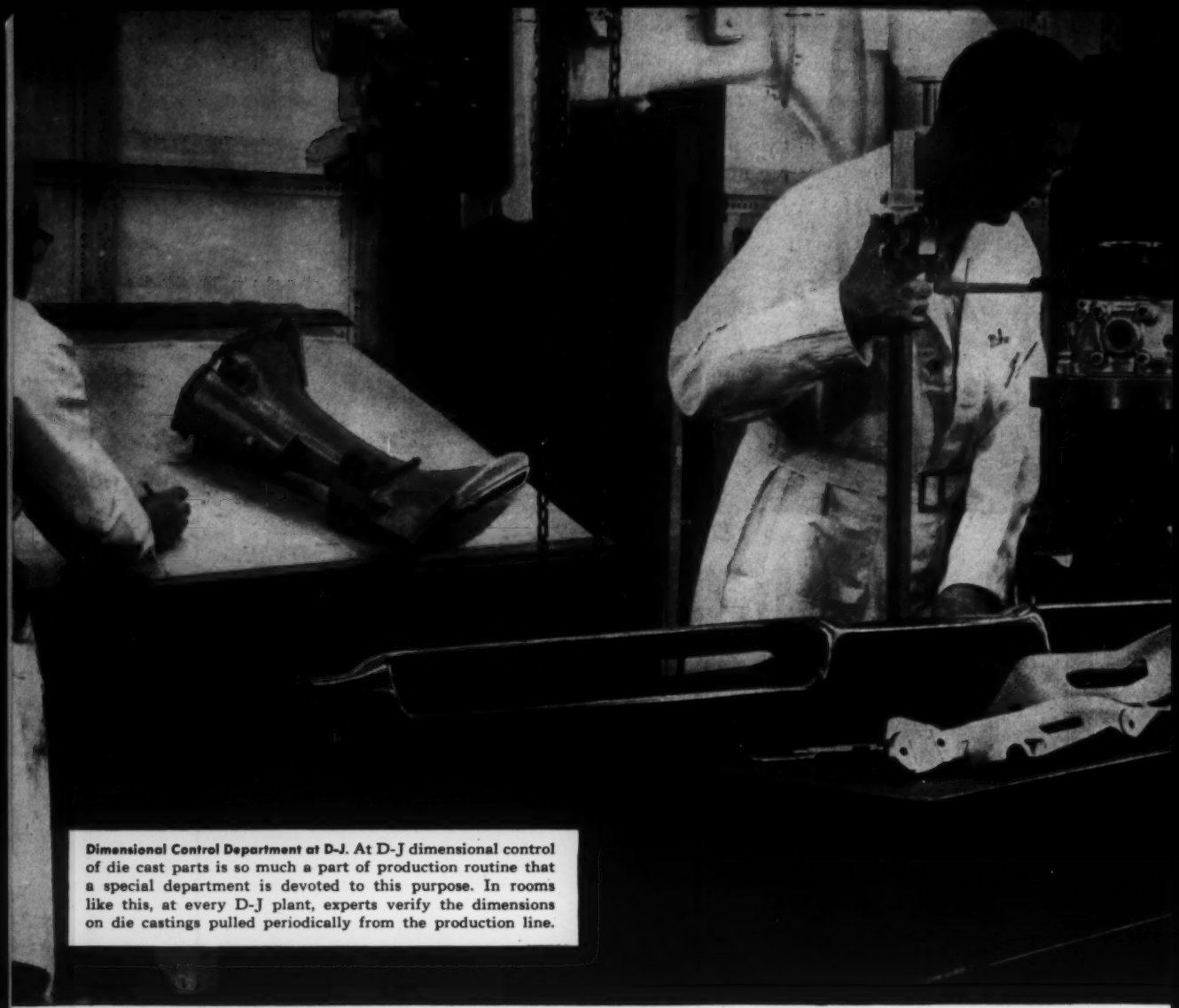
This NYFLEX flexible gear coupling has a one-piece sleeve weighing only four ounces! The entire assembly, including high-strength steel hubs and retaining rings, weighs just 3½ pounds. It's the lightest, most compact flexible gear coupling you can buy. Another outstanding "first" from Sier-Bath, pioneer producer of flangeless, one-piece flexible gear couplings.

The NYFLEX coupling gives you several innovations in design and performance. It never needs lubrication . . . Takes almost 5° misalignment . . . Can be run equally well in either horizontal or vertical installations . . . Operating temperatures may be as high as 150°F. . Wide range of horsepower capacities and shaft speeds to 5000 rpm. And it's priced as low as *half the cost* of comparable all-steel couplings! Ten bore sizes available NOW from stock.

Bulletin N-1 gives the complete story of the new Sier-Bath Nyflex coupling. It's yours for the asking.

Sier-Bath
Founded 1905 Member A.G.M.A.

GEAR AND PUMP COMPANY, INC.
9254 Hudson Blvd., North Bergen, N. J.



Dimensional Control Department at D-J. At D-J dimensional control of die cast parts is so much a part of production routine that a special department is devoted to this purpose. In rooms like this, at every D-J plant, experts verify the dimensions on die castings pulled periodically from the production line.

Outboard motor housing

Instrument panel bezel

Single cylinder engine block

Pinspotter part

At Doehler-Jarvis . . . everything improved production methods

Automatic transmission parts illustrate how much can be done with die cast design. Notice the ganged fluid passageways. Not apparent, but incorporated into the design of each of these parts, are many features that make these parts usable much as they are . . . with a minimum of further manufacturing needed.

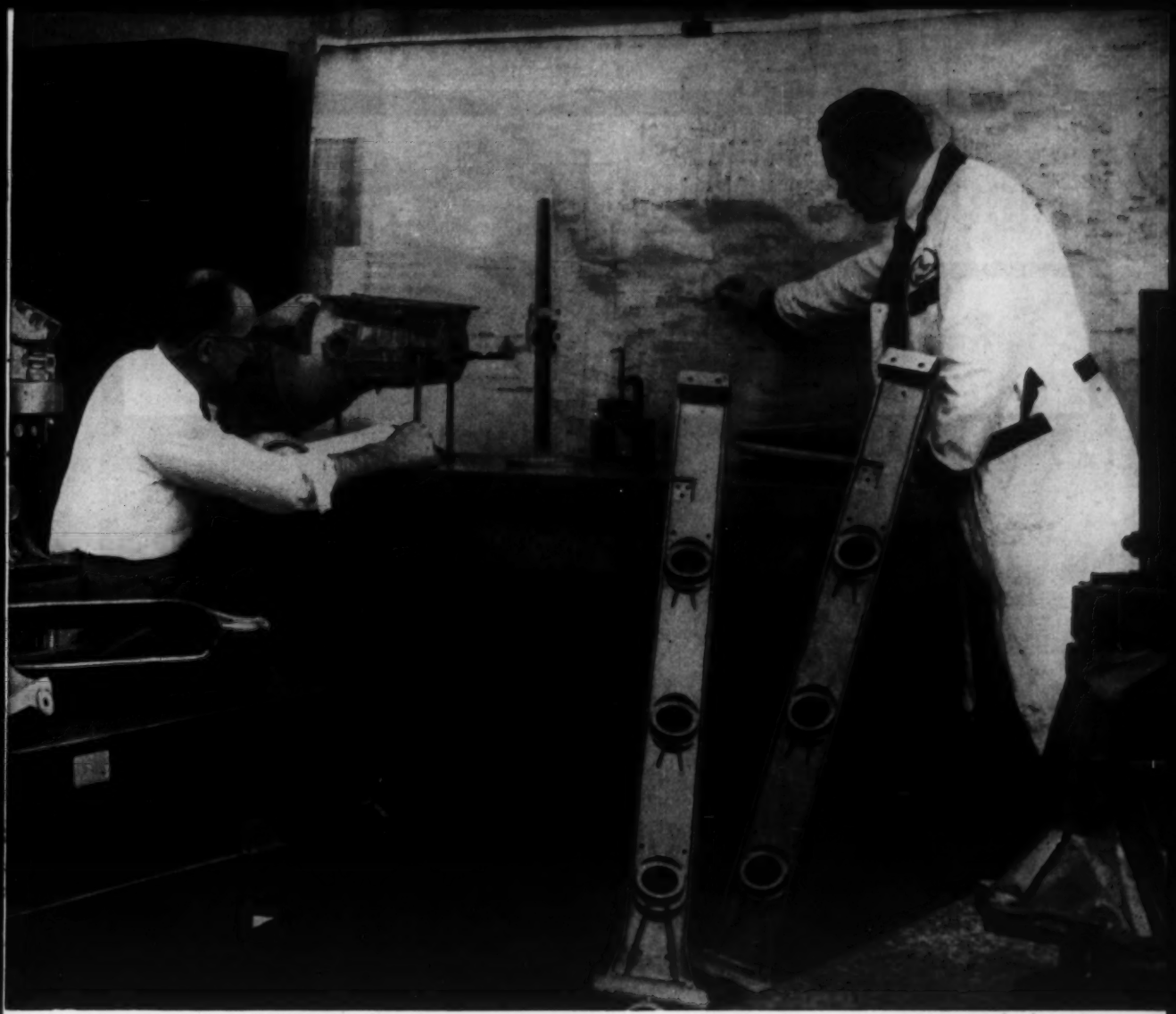
Only a handful of companies have ever taken *full* manufacturing advantage of the inherent opportunities presented by the purchase of die castings — opportunities to so design parts that production *all along the line* is simplified, speeded up, and made more economical.

Frequently die castings are bought under conditions where price is the dominant competitive factor. This approach sometimes makes good purchasing sense. And on the basis of price competition Doehler-Jarvis produces and sells more die castings per year than any other custom die caster.

But there is another, and often more rewarding, way to look at the purchase of die cast parts.

In many instances — most, in fact — a careful analysis of the part by experienced metal production men working in close coordination with equally experienced designers of the dies and the castings reveals ways to:

(1) reduce cost or improve performance of the casting itself.



Transmission housing | Pinspotter arms | Transmission par

needed to help you develop with the help of die castings

(2) introduce design features that eliminate one, many, or all of the machining, finishing or sub-assembling operations that must be accomplished before the part can be incorporated into the end product.

For example. Product engineers have only begun to realize the full range of applications made possible by the high fatigue strength inherent in aluminum die castings . . . by integrating several separate parts into one die casting . . . by ganging fluid passageways (as in automatic transmission designs).

Doehler-Jarvis customers who have taken this suggested broad viewpoint in purchasing their die castings find it pays off . . . sometimes enormously.

No producer of die castings can contribute more to this broad purchasing concept than Doehler-Jarvis.

In any category you care to name . . . research support . . . design help . . . skilled workmanship . . . versatility of metal working equipment (you can even buy *forgings, extrusions and stampings* from D-J) . . . sub-assembly facilities . . . choice of die casting metals and alloys . . . location of plants . . . delivery . . . Doehler-Jarvis provides more facilities than any other producer of die castings.

See what Doehler-Jarvis can do to help you realize the full potentials in die cast parts production. Call us in at an early stage in the design of your next new product or model change.

Doehler-Jarvis

Division of

NATIONAL LEAD COMPANY

General Offices: Toledo 1, Ohio

In Canada:

Barber Die Casting Co., Limited

Hamilton, Ontario

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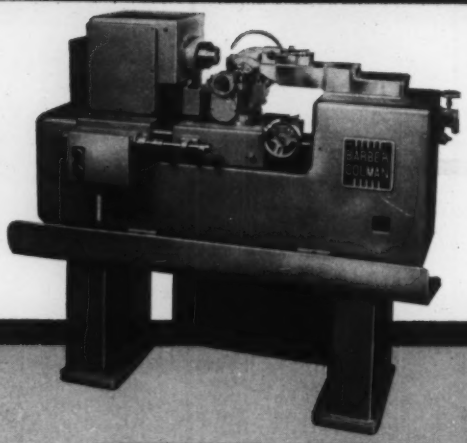
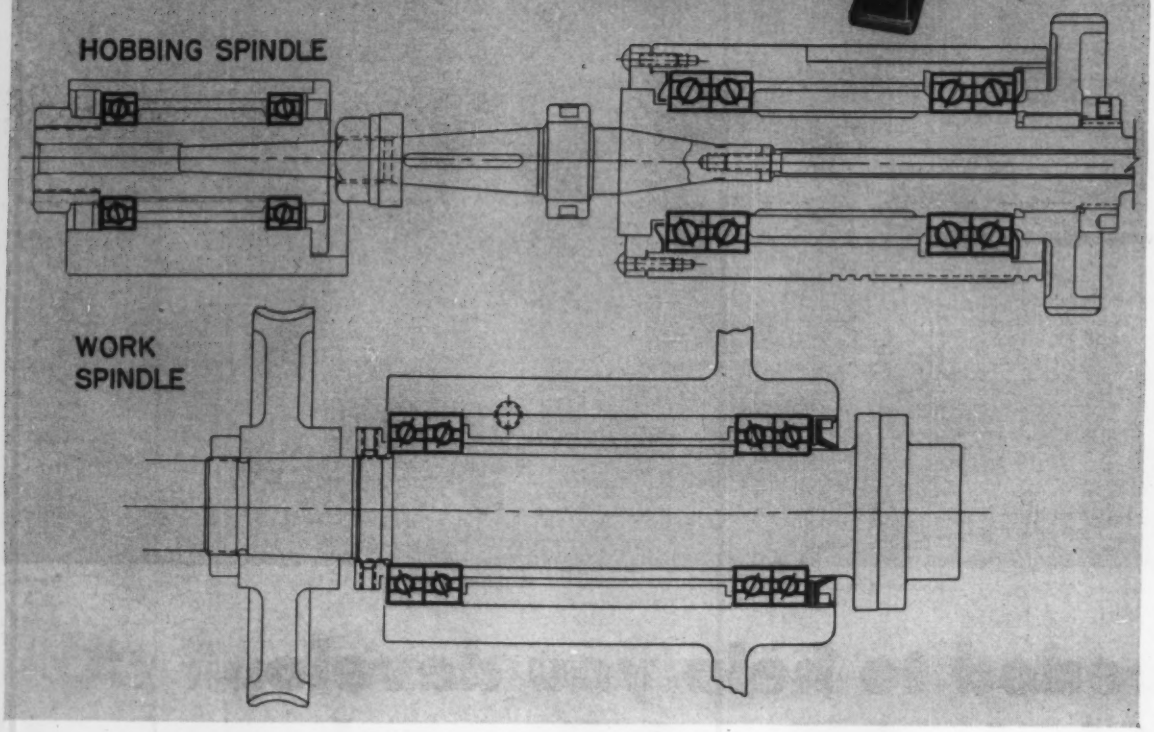


Barber-Colman 2½-4 Hobbing Machine hobs precision instrument spur gears up to 2½" in diameter, 2¼" in length. Efficient design features vertical hob spindle adjustment; swivel hob mounting; antifriction way bearings, self-contained, recirculating oil lubrication.



Relative rotation of hobbing machine spindles held accurate within 20 seconds using Fafnir Ball Bearings

New Barber-Colman 2½-4 machine precision-hobs spur gears for instruments

If two words can sum up the design of Barber-Colman's new 2½-4 Hobbing Machine, they are *accuracy* and *rigidity*.

Developed for hobbing AGMA Precision Class 3 fine-pitch spur gears for guidance systems, the 2½-4 has a minimum number of parts at points where deflection or inaccuracies might occur.

In selecting bearings which would complement the accuracy of the gears in the machine, Barber-Colman designers got the performance they wanted with Fafnir super-precision ball bearings. Single row, extra-light, counter-bore types, eight used in duplex pairs, help maintain indexing accuracy within *20 seconds*.

The application is typical of thousands Fafnir has handled where performance requirements put an extra premium on bearing selection. Chances are, Fafnir experience — plus breadth of line — can answer bearing problems you may have. Write The Fafnir Bearing Company, New Britain, Connecticut.

FAFNIR
BALL BEARINGS

10 Fafnir Extra-Light Super-Precision Ball Bearings, snug fit, support the Barber-Colman 2½-4 machine spindles. 4 variations, equipped with composition retainers, are available in this one series to meet specific load and speed requirements where exceptional rigidity is wanted.

Circle 451 on Page 19

cam-7-line

27,000 CANNON PLUG DESIGNS

FOR EVERY CONCEIVABLE APPLICATION

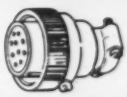
AIRCRAFT AND ELECTRONIC INSTRUMENTATIONS—MS, MS-A, MS-B, MS-E, MS-R SERIES, conforming to Specification MIL-C-5015D. Vibration-proof—Lightweight—Plugs are available with from 1 to 100 contacts. 15 different insert diameters and 260 contact layouts. 6 shell styles, MS 3100 to MS 3108 with all accessories. Environmental-Resisting MS-E and MS-R Series have interfacial sealing at mating faces and integral grommet seal at wire entry plus—grounding lugs and integral cable clamp.

GENERAL CIRCUITRY AND QUICK DISCONNECT—K, RK SERIES, with special acme thread. The all-purpose series with eight insert diameters available. Conduit and cable clamp entry types. 1 to 110 contacts. 10, 15, 30, 40, 60, 80, 115 and 200 amp. silver plated contacts. High quality phenolic, melamine, and formica insulators. Cadmium-plated aluminum alloy shells.

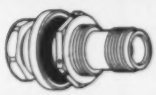
UNIT-PLUG-IN RACK PANEL-DP, DPB, DPD, DPD2, DPD2R, DPJ, DPS SERIES, available with from 2 to 180 contacts in rectangular inserts. With and without shells; coaxial and high voltage contacts. Permit quick disconnect, interchange, replacement, testing, and inspection of assemblies and sub-assemblies.

AUDIO AND LOW-LEVEL CIRCUITS—P, XLR, XK, O, UA, BRS SERIES, in many shell styles and insert layouts. Straight and 90° angles. Latch-lock types. Wall-mounting, panel, locknut mounting, and adapter receptacles, single and two-gang. 10 and 30 amp. contacts, coaxials.

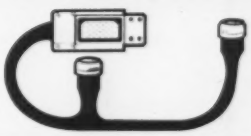
MINIATURE AND SUB-MINIATURE—D, US, DPA, DPX, AND K-MINIATURE SERIES, designed for amplifiers, miniature indicators, computer circuits, telemetering equipment, and general instrumentation of limited space requirements. Variety of shell styles, junction shells, and insert arrangements. Available with from 2 to 50 contacts, plus coaxials.



COAXIAL RF SERIES—available in a wide range of Series and types from sub-miniature to large cable applications. New Cannon adapters available for use with latest cable developments. Cannon's latest RF Plugs include aluminum versions designed for use where weight-saving is a critical design criteria.



GM AND PLUG HARNESS SYSTEMS—Cannon produces a wide range of GM Plugs to fit specific missile applications, ranging from straight umbilical dis-connects to stage-separation dis-connects. Cannon also produces Plug Harness Systems featuring MS or other specified plugs and cables as one unit, available with various contact types and sizes. From 8 to 140 contacts. Highest quality and proven reliability. Varied remote disconnect methods actuated by hydraulic, pneumatic, explosive, or manual means.



The Cannon Electric Company also has available a wide variety of plugs for Battery-Power, Fire-wall, Watertight, Printed Circuit, and other applications, as well as "Kwik-Term" Terminals and DC Solenoids.

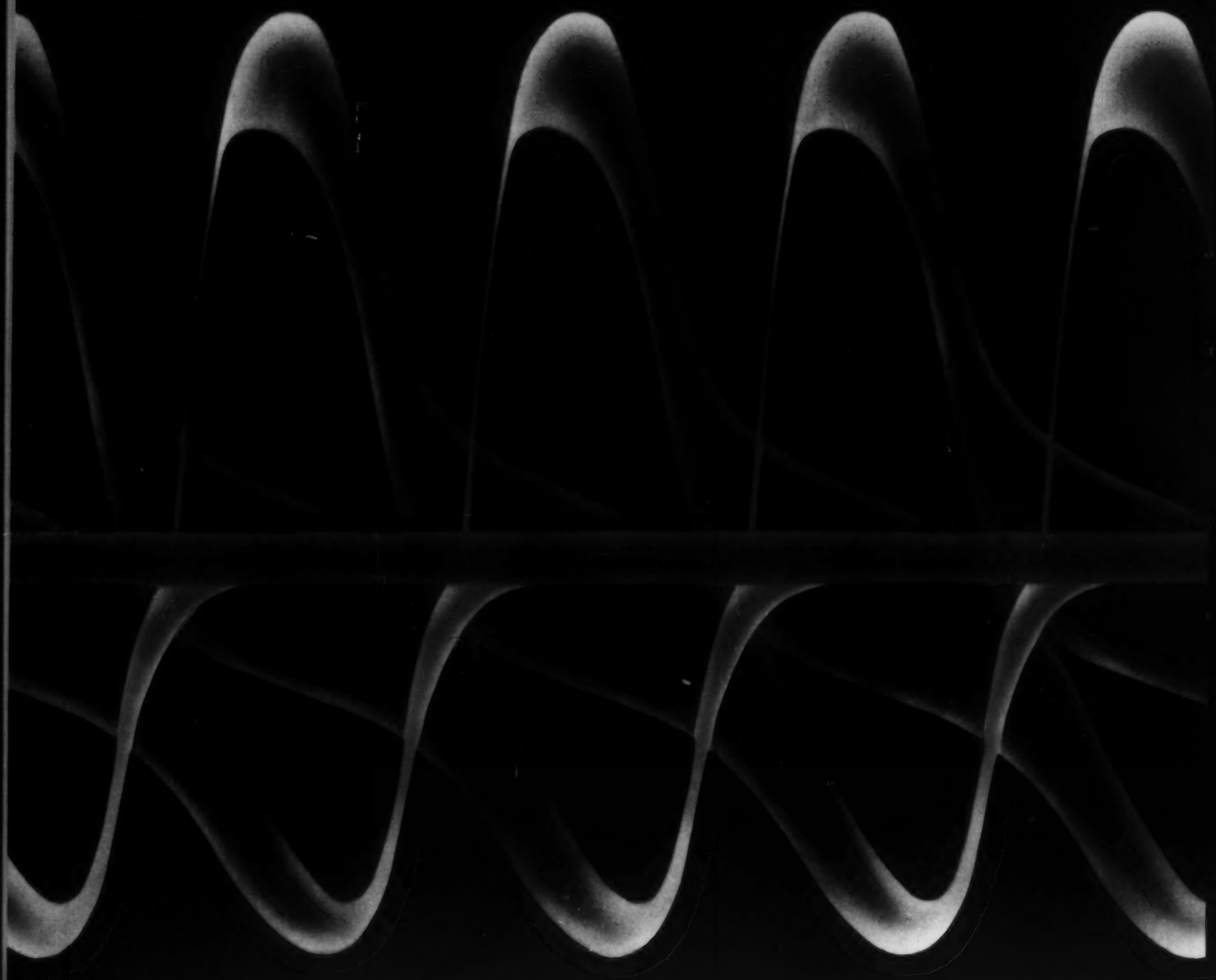
FOR ADDITIONAL INFORMATION on the typical designs illustrated . . . other configurations for your specific applications . . . or the design, engineering and manufacture to your special needs . . . write to Cannon Electric Company—3208 Humboldt Street, Los Angeles 31, California. Please refer to Dept. **185.**

LARGEST FACILITY IN THE WORLD FOR PLUG RESEARCH-DEVELOPMENT-MANUFACTURE

CANNON PLUGS

MARCA REG. IN MEXICO

Factories in Los Angeles, Santa Ana, Salem, Toronto, London, Paris, Melbourne, and Toyko. Distributors and Representatives in the Principal Cities of the World.



The cathode ray oscilloscope is one of science's and industry's most perceptive instruments for determining uniformity of operation. The pattern reproduced here is a harmonically modulated sine wave of exact uniformity.

Uniformity is Malleable

Just as the input of an oscilloscope can be controlled to produce repetitive patterns, so can consistently uniform metal parts be produced with Malleable iron because of modern, scientific controls. The unique method by which all Malleable castings are made and the exacting techniques employed by Malleable foundries assure Malleable users of castings that are uniform, part after part, regardless of size or shape. This uniformity, combined with unparalleled physical and mechanical properties, ideally suits Malleable castings for modern America's quality products.

For information or service, call on one of the progressive firms that identify themselves with this symbol—

MEMBER

MALLEABLE

CASTINGS COUNCIL

If you wish, you may inquire direct to the Malleable Castings Council, Union Commerce Building, Cleveland 14, Ohio, for information.

Better Products at Lower Cost Result From Malleable Uniformity Controls

Uniform quality — whether for five or five million pieces — is essential to maintain product quality and increase manufacturing efficiency. With accelerating frequency, Malleable castings contribute their unique uniformity in critical applications where durable, reliable components are necessary.

Key to Uniformity is Control

Malleable iron is produced under closely controlled manufacturing techniques. From charge composition and molding sand properties, through final inspection, every critical factor is held constant by using the most modern techniques of metal analysis, process control and inspection.

Internal Uniformity

This versatile engineering material is achieved through converting the base white iron into tough Malleable iron by a controlled heat treating process. Malleable's internal structure exhibits excellent uniformity, an important factor in assuring the dependable performance of intricately designed components.

External Uniformity

Fundamental to the casting process is the ability to produce a given shape, time after time, in either small or large quantities. Metal can be placed exactly where it is needed . . . eliminated where it is not. Good design — achieved through close cooperation between the customer and the foundry — can assure the necessary tolerances and the lowest possible finished part cost. Modern techniques of production and inspection are used to insure top quality, dimensionally accurate castings.

The life of every motorist rides in complete safety on Malleable wheel hubs of unerring uniformity.

Uniformity Proven by Use

The final test of any part is how well it stands up in actual service. Under continuous cyclic and shock loading, the millions of Malleable wheel hubs, which are in service on the front end of every American-made car, have compiled an enviable record of proven uniformity. Another dramatic example of Malleable's uniformity is proved in the old adage "A chain is only as strong as its weakest link." Miles of Malleable chain, carrying tremendous loads year after year without failure, demonstrate the uniformity of every cast link.

New techniques for controlling every element of Malleable production are the result of intensive research done by Malleable foundries in their continuing search for ways to make Malleable even more versatile and indispensable to industry.

More Information Available

Your copy of *Data Unit 103—Uniformity* — is available from any member of the Malleable Castings Council. If you prefer, write direct to Malleable Castings Council, Union Commerce Building, Cleveland 14, Ohio.

These companies are members of the

MALLEABLE CASTINGS COUNCIL

CONNECTICUT
Connecticut Mall. Castings Co., New Haven 6
Eastern Malleable Iron Co., Naugatuck
New Haven Malleable Iron Co., New Haven 4

DELAWARE
Eastern Malleable Iron Co., Wilmington 99

ILLINOIS
Central Fdry. Div., Gen. Motors, Danville
Chicago Malleable Castings Co., Chicago 43
Moline Malleable Iron Co., St. Charles
National Mall. and Steel Castings Co., Cicero 50
Peoria Malleable Castings Co., Peoria 1
Wagner Castings Company, Decatur

INDIANA
Link-Belt Company, Indianapolis 6
Muncie Malleable Foundry Co., Muncie
Terre Haute Mall. & Mfg. Corp., Terre Haute

MASSACHUSETTS
Belcher Malleable Iron Co., Easton

MICHIGAN
Albion Malleable Iron Co., Albion
Auto Specialties Mfg. Co., Saint Joseph
Cadillac Malleable Iron Co., Cadillac
Central Fdry. Div., Gen. Motors, Saginaw

MINNESOTA
Northern Malleable Iron Co., St. Paul 6

NEW HAMPSHIRE
Laconia Malleable Iron Co., Laconia

NEW JERSEY
Meeker Foundry Company, Newark 4

NEW YORK
Acme Steel & Mall. Iron Works, Buffalo 7
Frazer & Jones Company Division Eastern Malleable Iron Co., Solvay
Oriskany Malleable Iron Co., Inc., Oriskany
Westmoreland Mall. Iron Co., Westmoreland

OHIO
American Malleable Castings Co., Marion
Canton Malleable Iron Co., Canton 5
Central Fdry. Div., Gen. Motors, Defiance
Dayton Mall. Iron Co., Ironton Div., Ironton
Dayton Mall. Iron Co., Ohio Mall. Div., Columbus 16
Maumee Malleable Castings Co., Toledo 5
National Mall. and Steel Castings Co., Cleveland 6

PENNSYLVANIA
Buck Iron Company, Inc., Philadelphia 22
Erie Malleable Iron Co., Erie
Lancaster Malleable Castings Co., Lancaster
Lehigh Foundries Company, Easton
Meadville Malleable Iron Co., Meadville
Pennsylvania Malleable Iron Corp., Lancaster

TEXAS
Texas Foundries, Inc., Lufkin

WEST VIRGINIA
West Virginia Mall. Iron Co., Point Pleasant

WISCONSIN
Belle City Malleable Iron Co., Racine
Chain Belt Company, Milwaukee 1
Federal Malleable Company, West Allis 14
Kirsh Foundry Inc., Beaver Dam
Lakeside Malleable Castings Co., Racine
Milwaukee Malleable & Grey Iron Works, Milwaukee 46

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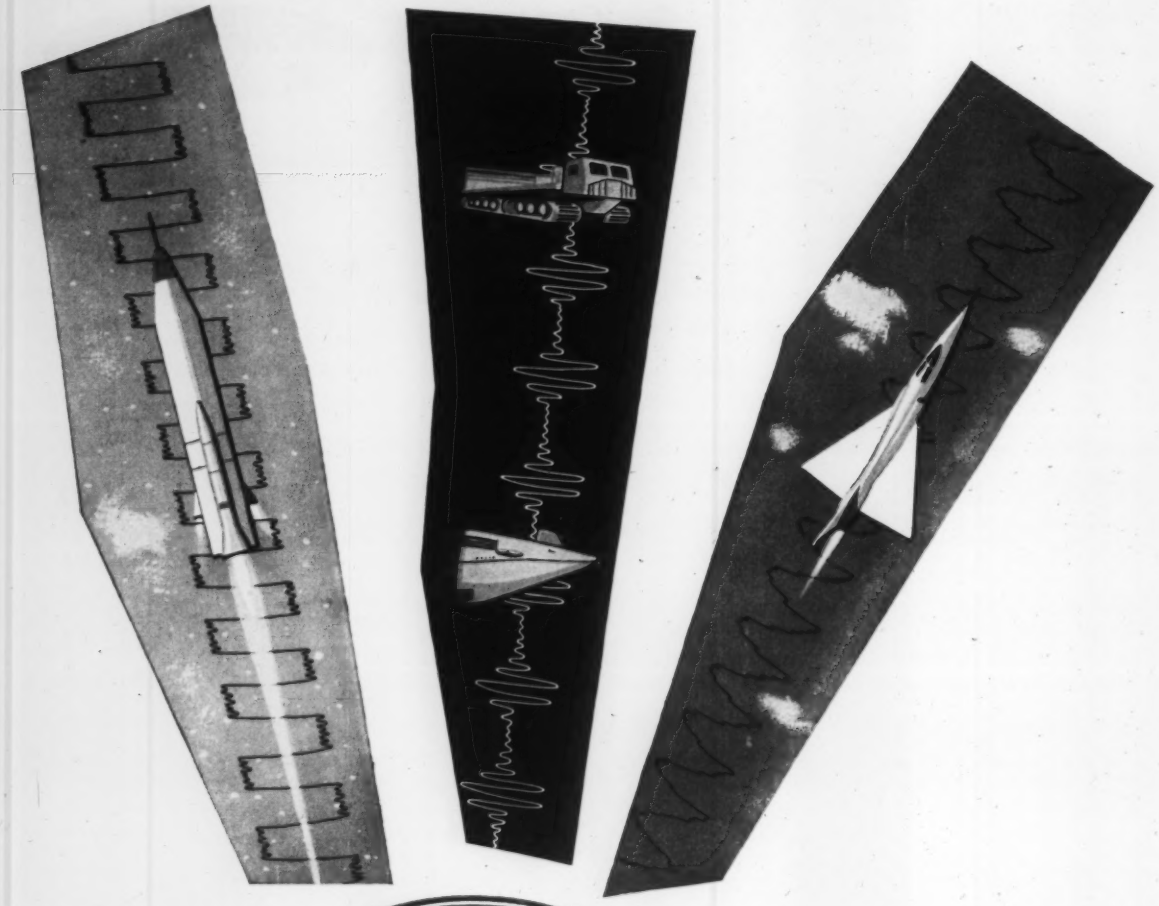
FOR OPTIMUM PROTECTION FROM VIBRATION/SHOCK/NOISE



utilize LORD capabilities

Greater reliability—*your* problem? LORD can help you do something about it. Protective mounting systems, designed, tested and produced at LORD, insure high reliability for sensitive equipment.

LORD is a diversified, capable technical organization, supported by modern facilities and prepared to complete challenging assignments in controlling vibration, shock and noise.

Your project can benefit from experience gained in working on Atlas, Talos, Jupiter, B-58, F-105, F11F, Convair 880, ground support, vehicular, shipboard, submarine and other advanced classified projects.

LORD is ready to work as an integral member of your team.

LORD MANUFACTURING COMPANY • ERIE, PA.

FIELD ENGINEERING OFFICES

ATLANTA, GEORGIA · CEdar 7-9247
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NEW YORK, N. Y. · Circle 7-3326
PHILADELPHIA, PA. · PEnnypacker 5-3559
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"In Canada—Railway & Power Engineering Corporation Limited"

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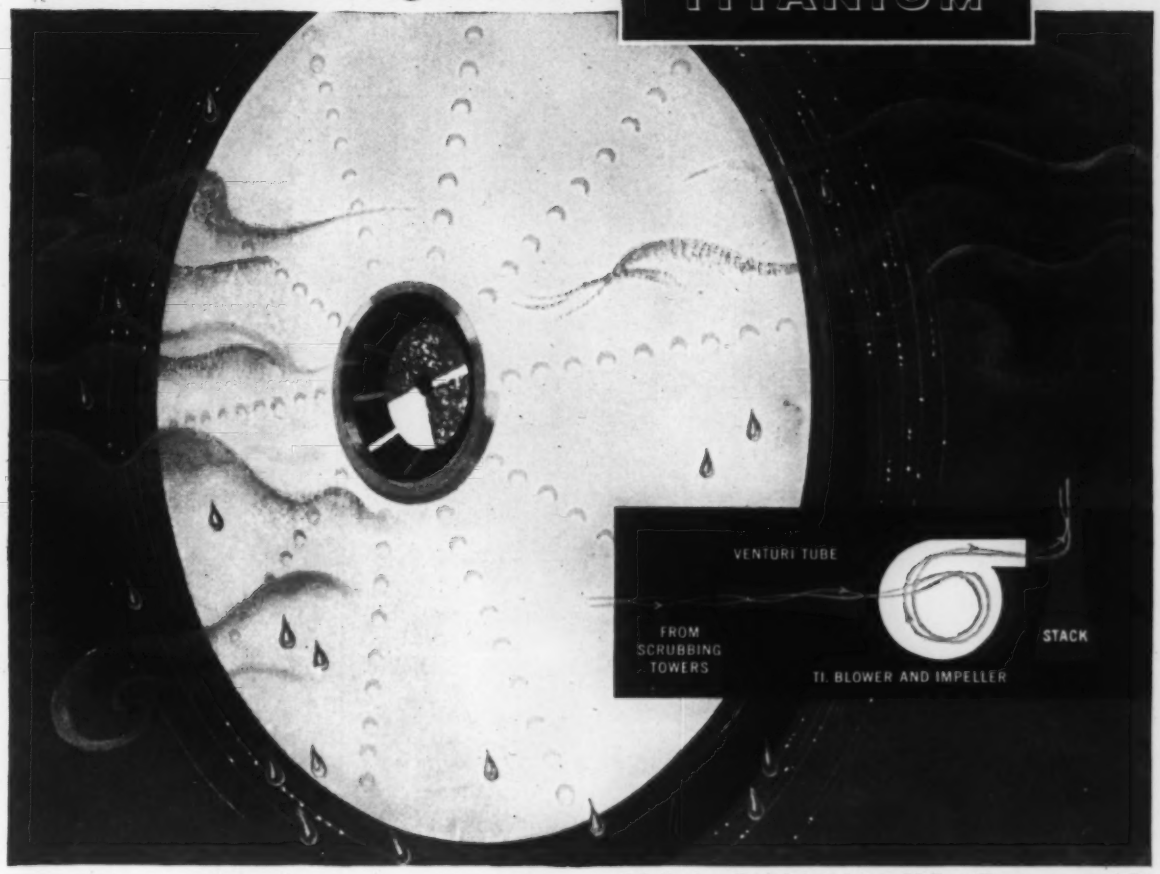
Cost cutting ideas in **TITANIUM**



24" dia. impeller fabricated from Mallory-Sharon commercially pure titanium. Diagram shows application in gas scrubbing system.

TITANIUM IMPELLER PROVED "BEST BY TEST"

...outlasts other metals more than 40 to 1

CORROSION TEST DATA
Results after 16-day exposure

MATERIAL	CORROSION RATE INCHES YEAR	COMMENTS
Pure Titanium	0.0006	No visual effect
Pure Zirconium	0.027	Slight pitting
Nickel-Base Alloy "A"	0.052	Slight uniform corrosion
Nickel-Base Alloy "B"	0.206	Sample etched
Nickel-Base Alloy "C"	0.217	Sample etched
Nickel-Base Alloy "D"	5g. Sample consumed	
300 Series Stainless "A"	0.442	Sample deeply etched
300 Series Stainless "B"	0.510	Sample deeply etched
Nickel-Copper Alloy	50g. Sample consumed	
Nickel	55g. Sample consumed	
Metallic Silver	.20% Gain in Weight	

Approximate conditions of test: *Temperature—40° to 90°F. Humidity—atmosphere more than saturated. Primary corrosive agents—Hypochlorous acid, Hydrochloric acid, Sodium Hypochlorite, Caustic Soda, Free Chlorine.*

A leading chemical company faced a serious problem in a multi-metal chloride "gas scrubbing" system. The system's high-velocity blower, handling corrosive wet gases at 40° to 90°F., operated at 3500 rpm. Peripheral speeds were too high to use a plastic coated steel impeller. When one was tried, it lasted just two days.

Titanium was then considered with other metals, and evaluation tests run that proved titanium was by far the best. (See test results at left.) An impeller fabricated from Mallory-Sharon commercially pure titanium was installed. To date, it has given *10 months' continuous service* and is still in use. And *the original cost was no more* than for a nickel-base alloy impeller.

We'll gladly help you in applying titanium for highly corrosive service. For further information, write for "Cost Cutting Ideas in Titanium for Chemical Pumps, Valves and Accessories". Address: Commercial Market Development, Dept. B, Mallory-Sharon Metals Corp., Niles, Ohio.

MALLORY SHARON

MALLORY-SHARON METALS CORPORATION • NILES, OHIO

Integrated producer of Titanium • Zirconium • Special Metals

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VALVAIR'S one universal pilot operates any SPEED KING® valve!

Valvair's one *universal* pilot—completely interchangeable on all Speed King valves—has only two moving parts. It's built to handle your toughest jobs.

Why complicate production, maintenance and parts inventory on the machines you build or operate, by using control valves that require an assortment of pilots?

For peak performance . . . unmatched reliability . . . minimum parts inventory . . . specify Valvair Speed Kings, the valves with *universal* pilots!

8002

For more information, write for Bulletin D-58. Address Dept. **MD-459,** Valvair Corporation, 454 Morgan Ave., Akron 11, Ohio.

Representatives in principal cities.

Valvair AKRON 11, OHIO

A DIVISION OF INTERNATIONAL BASIC ECONOMY CORPORATION

Other INDUSTRIAL DIVISIONS of IBEC: The Sinclair-Collins Valve Co. The Bellows Co., Akron, Ohio • V. D. Anderson Co., Cleveland, Ohio.

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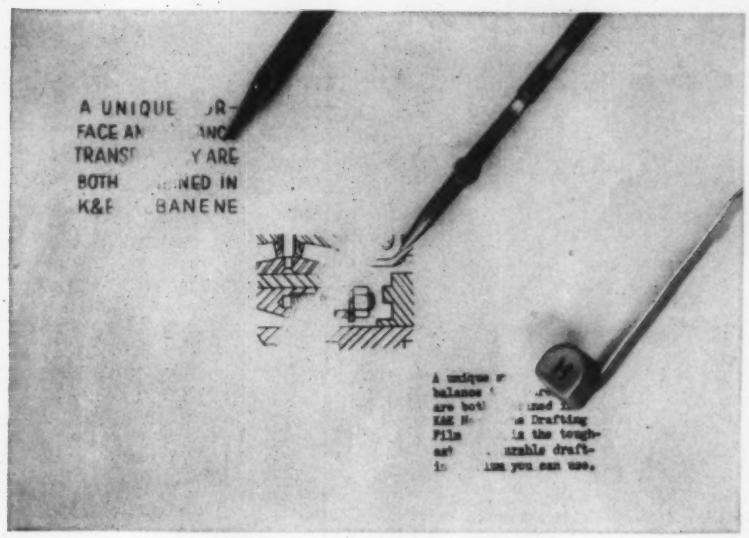
Some Ideas

for your file of practical information on drafting and reproduction from

KEUFFEL & ESSER CO.



Now you see it . . . now you don't. Pencil, ink and typing all register sharply, erase completely on the K&E "engineered surface."

The K&E "Engineered Surface"

All K&E paper, cloth and film has one extremely individual characteristic. It's what K&E calls its "engineered surface"... a unique surface designed and applied by K&E, right in its own plant, to every roll and sheet of prepared tracing paper, cloth and film. It means controlled drafting qualities far beyond anything the base material alone can normally provide, with a surface tooth that's exactly right and uniform. Whatever's penciled, inked or typed onto it goes on crisply and sharply . . . shows up clearly and stays that way. Furthermore, the "engineered surface" lets you erase if you want to, easily and quickly and without any of those leftover ghost lines that drive you crazy when they show up in reproductions. And remember, only with K&E do you get all the advantages of an "engineered surface," no matter which paper, cloth or film you're interested in.

About HERCULENE (TM) The Newest of Films

Frankly, we think K&E Herculene Drafting Film is a real discovery. It has all the properties of the K&E "engineered surface" . . . exceptional "take," adhesion and erasability . . . plus the toughness and durability of its Mylar® base. What's the latter? It's a polyester film, developed by DuPont, that's uncommonly strong and virtually indestructible . . . waterproof and almost immune to the effects of age, heat, ultraviolet exposure and handling. With our K&E "engineered surface" added, it becomes K&E Herculene Drafting Film . . . the toughest, most durable drafting medium yet to reach the drafting room. And the surface will last indefinitely, without flaking off or chipping off.

Some Points About Paper...

K&E Albanene® Tracing Paper is the largest selling tracing paper in the world today. Why? Because Albanene is the *only* prepared tracing paper which has an "engineered surface." All other brands depend for their pencil tooth solely on the natural surface texture of the paper itself, which varies from fine to coarse . . . often on the same sheet.

Albanene invariably gives you sharp, clear pencil lines, superb reproductions. It has a solid transparentizer that is chemically stable and can't leak out, ever. This permanent transparentizing means that you'll never get white, opaque spots, even from contact with drafting tape. Try the drafting tape test yourself.

. . . and its package

And now, all Albanene paper in rolls is packaged in the new square carton for better protection and easier storage. Your rolls stay neat and clean while in use, and the cartons will do double duty in helping you to store finished tracings. In fact, some companies are rearranging their filing systems by using Albanene cartons, which hold large numbers of rolled-up drawings and stack simply and neatly.

Some Facts About Cloth

When you want cloth, think first of K&E Phoenix® Tracing Cloth. Besides the K&E "engineered surface" with the superb "take", adhesion and erasability for pencil, ink or typing, K&E Phoenix has all the advantages of a water-resistant, chemically-inert coating that won't soften even under high heat and won't discolor, become brittle or flake off the base. You can even clean both sides with a damp cloth, without worrying about moisture stains.

And Some Tips On Erasing

All K&E drafting media give you excellent erasability, but there's a right way to erase on each one. On cloth and film, harsh, gritty erasers can destroy the surface. You'll get the best results with plastic erasers, such as the Richard Best "Tad" and the Eberhard Faber "Race Kleen." Moisten them for removing ink and stubborn typing; use them as they are for removing pencil lines. Large areas of ink can be removed completely without damage by using a moist cloth and Bon Ami cleanser. On Albanene, electric erasing machines are fine if used with a soft eraser.

The Choice Is Up To You

When it comes to selecting K&E paper, cloth or film for the job at hand, we have to leave the choice to you. We're not being indecisive . . . it's just that you're the only one who knows the particular problem you have and which product solves it best. But remember . . . K&E has a *complete* line of paper, cloth and film . . . and only K&E puts a special "engineered surface" on all three media to provide a well-balanced, uniform surface suited to the base material.

KEUFFEL & ESSER CO., Dept. MD-4, Hoboken, N. J.

Please send me more information and samples on the following:

☐ K&E Herculene ☐ K&E Albanene ☐ K&E Phoenix

Name & Title_____

Company & Address_____

_____ 1377

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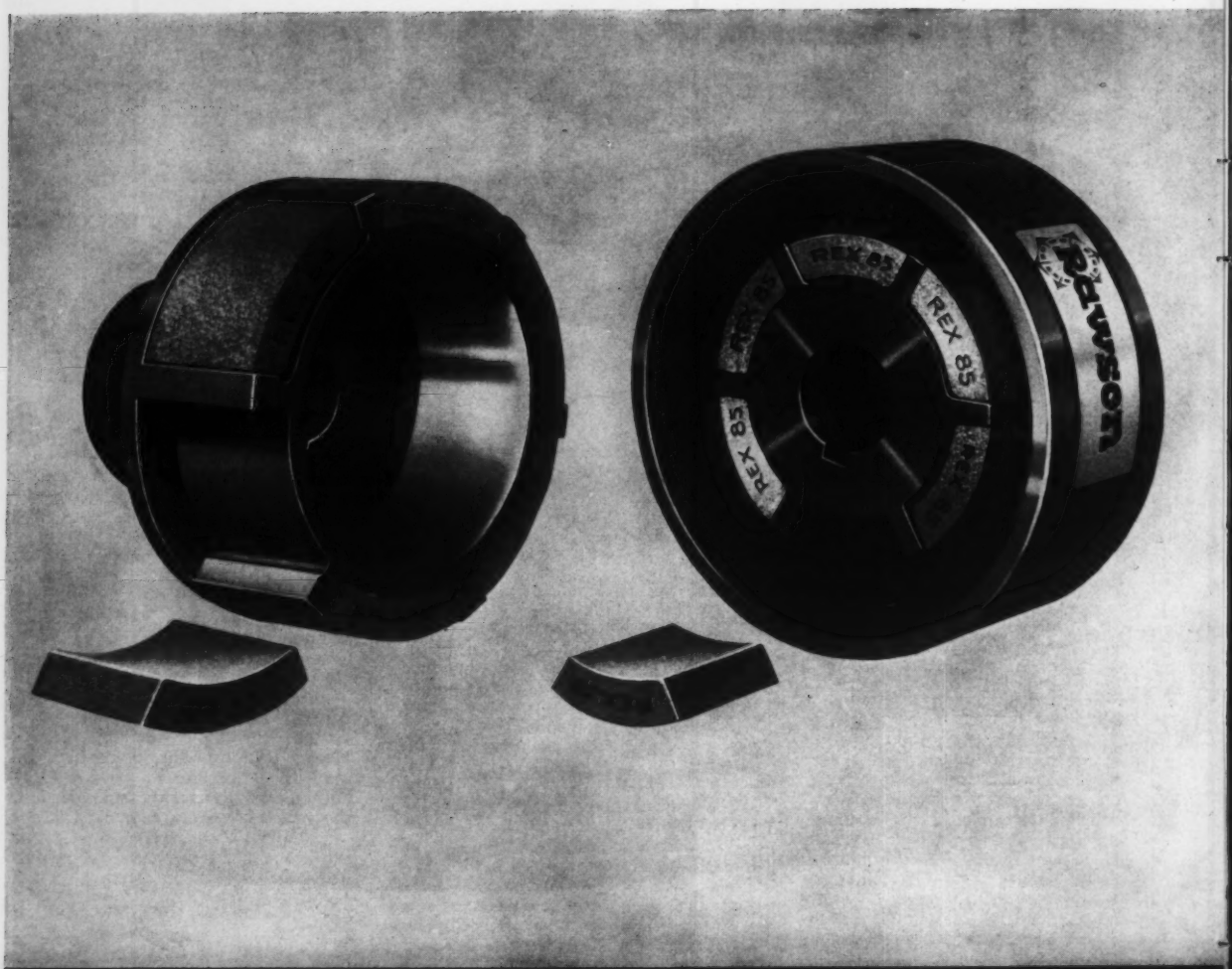
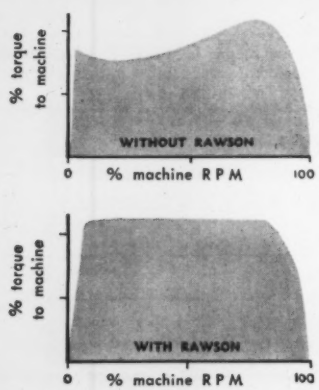
For Cushioned

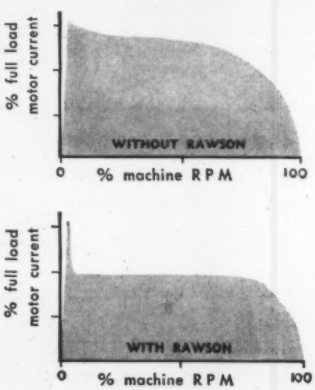


How Rawson Improves Motor Performance

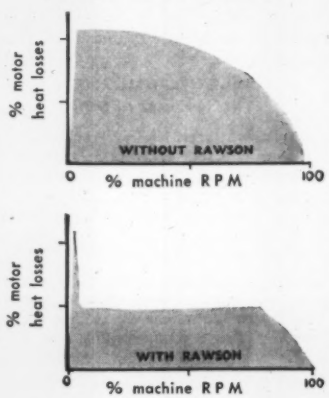
delivered starting torque



motor starting current



motor heat losses



"no load" Starts

Specify Rawson

Automatic Centrifugal Clutches and Clutch Couplings

Here is a major break-through in the development of automatic centrifugal clutches and clutch couplings! Rawson clutches and clutch couplings are designed with patented, exclusive metallic friction shoes instead of using fluid coupling devices or "brake lining" type materials. They deliver 100% slip-free power, provide full overload protection, permit smooth and gradual starting of high inertia equipment. This eliminates the need for costly special high torque starting motors and low-voltage starting equipment.

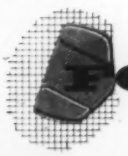
The segments, or shoes, in Rawson clutches and clutch-couplings are free-moving parts. As the driving half of clutch picks up speed, centrifugal force causes the shoes to contact the inside surface of the outer race, which is attached to the load or driven equipment. The shoes slip momentarily until friction at full speed causes the driven half to rotate in complete engagement with the driving half, both members then rotating as a unit without slippage or power loss. Jamming or overload of driven equipment causes clutch to slip — protecting motor against excessive overloading.

Rawson clutches and couplings drive in either direction and transmit up to 2,000 H.P. from nearly every motive source including A.C. and D.C. motors, diesel and gasoline engines or turbines. They function as direct couplings or as indirect drives through V-belts, chains or gearing and can be furnished with delayed shoe engagement for standby or dual drive units with load limit on starting or running. Rawson clutches and couplings are simple in design, fast and easy to install, entirely mechanical for trouble-free operation and they never require adjustment.

For increased efficiency, lower first costs, reduced maintenance and utmost protection even for the most delicate driving and driven equipment, specify Rawson clutches and clutch couplings. Ask your Rawson distributor or write us direct for your free copy of Rawson Catalog No. 141.

FORMSPRAG COMPANY
23603 Hoover Road, Dept. 101
Warren (Detroit), Michigan

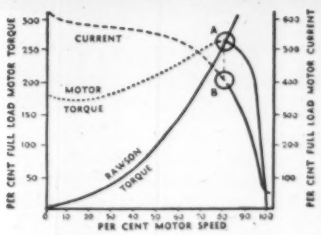
Distributorships available in selected areas. Write for details.



FORMSPRAG COMPANY

World's Largest Exclusive Manufacturer of Over-running Clutches

and Protects Motors

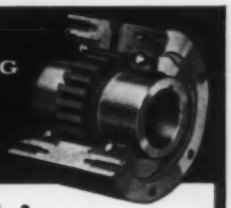


Using Rawson clutches or clutch couplings in a start-drive system lets you switch from costly high-torque motors to smaller standard, general-purpose motors for starting high-inertia loads.

Chart above shows how Rawson permits a standard NEMA "B" motor to start without load. The clutch does not fully engage until peak motor torque speed (A) is reached. Motor acceleration time is cut to a fraction of a second, decreasing the peak current period and allowing more efficient motor operation (B).

Thus, expense of reduced-voltage equipment is eliminated with the Rawson cushioned "no-load" starts, even on the heaviest machinery.

FORMSPRAG OVER-RUNNING CLUTCHES... UNIVERSAL APPLICATION!



OVER-RUNNING • INDEXING • BACKSTOPPING

Modern Formsprag sprag-type clutches are practically unlimited in power transmission applications. They are universally used in automotive, aircraft and general industries. Complete range of capacities from small clutches at 50 in. lbs. to large bore backstops up to 136,000 ft. lbs. Complete Formsprag standard line includes bore sizes from ⅜" to 12". Specials engineered to your requirements. Write for the new Formsprag catalog.

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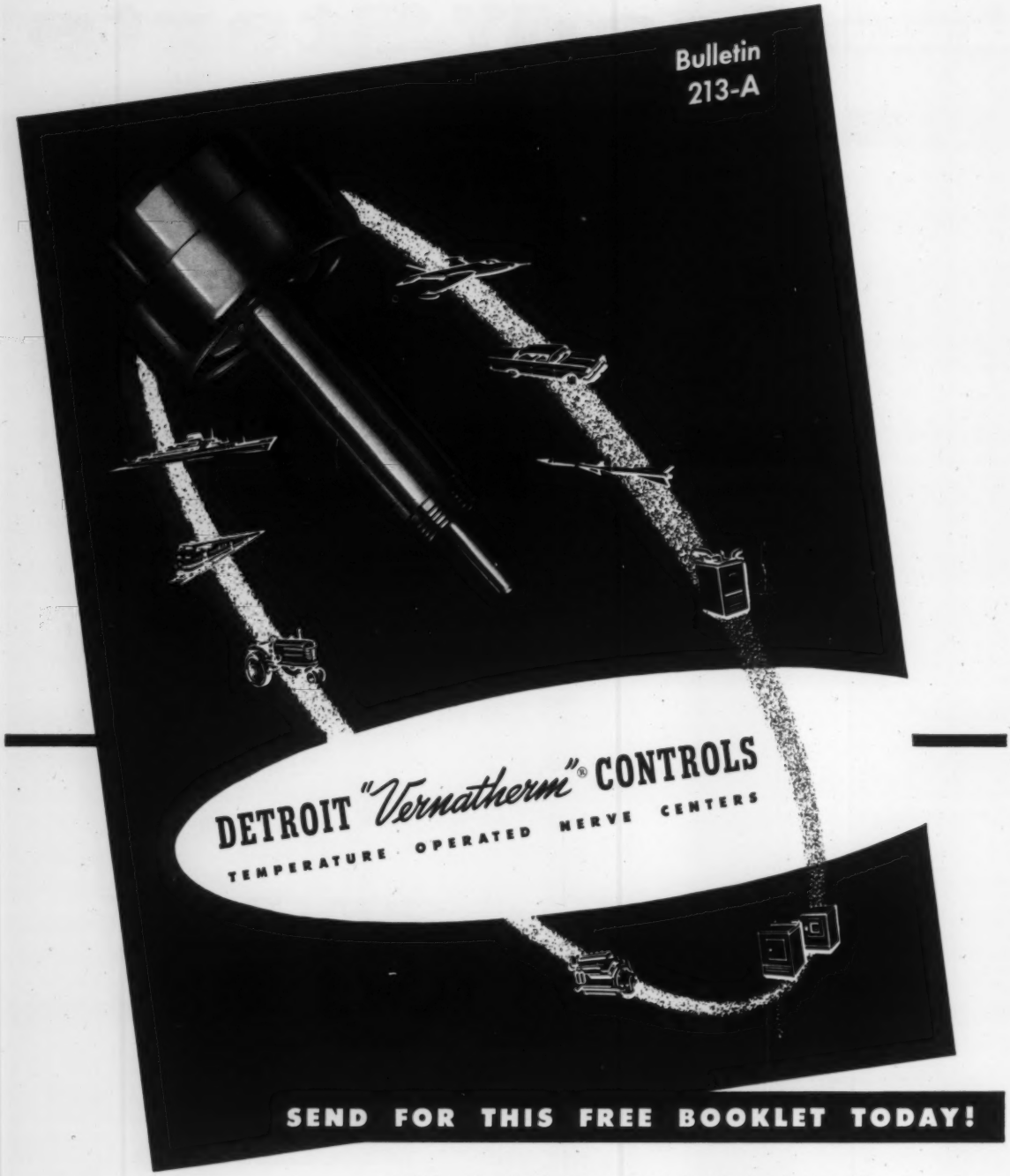

. . . it describes the Vernatherm control and where it is used in a variety of industries. The thermostatic element can lift up to a 250-pound load at temperature ranges from sub-zero to 450°F. Write to Detroit Controls Division of American-Standard, 5900 Trumbull Avenue, Detroit 8, Mich., for bulletin no. 213-A.

American-Standard and Standard® are trademarks of American Radiator & Standard Sanitary Corporation.

AMERICAN-Standard

DETROIT CONTROLS DIVISION

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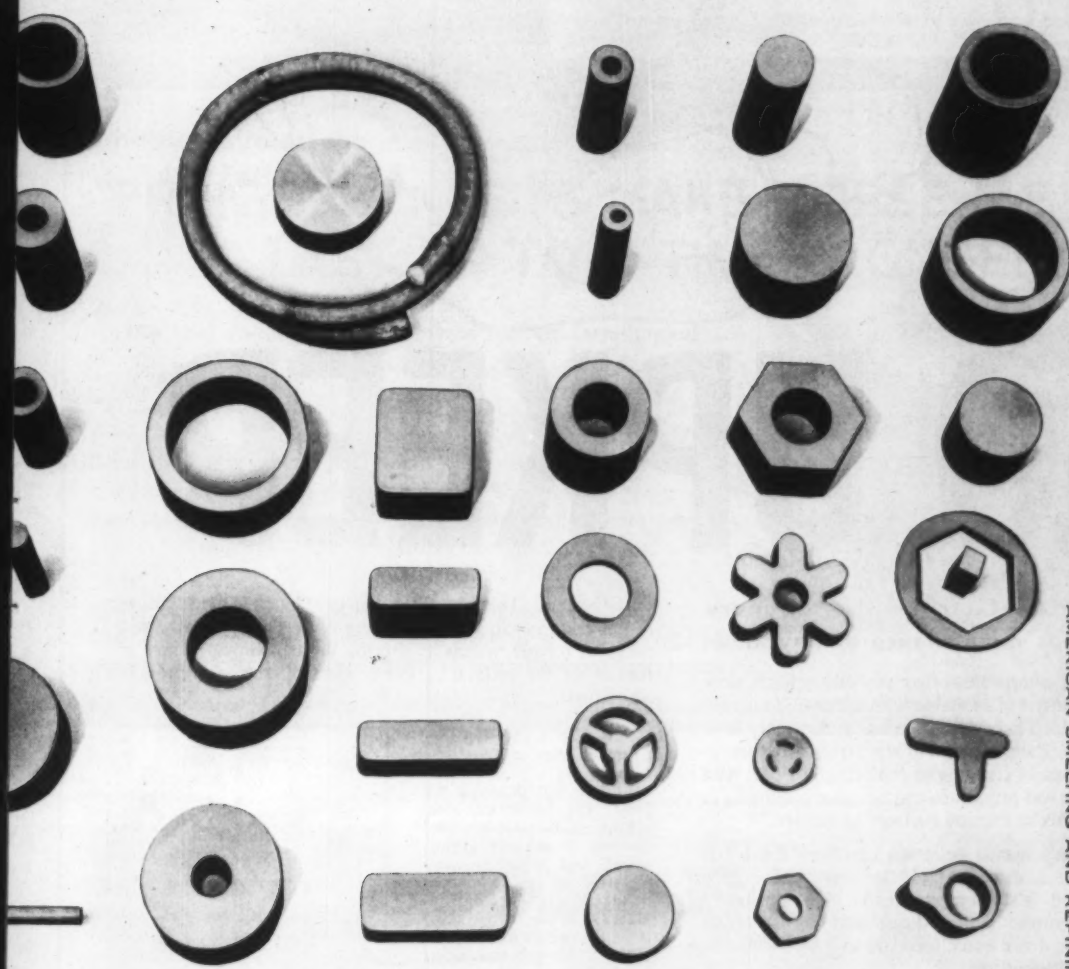
Circle 460 on Page 19→

In continuous lengths: the bronze casting you want in the shape you want! Asarco will custom cast practically all standard tin-bronze alloys in the shapes, lengths and diameters you need. Custom-shapes in long lengths instead of individual castings. Uniformity and machinability of bronze alloys with no hard or soft spots: no sand, dirt, or dross to dull tools or reduce cutting speeds. Superior physical characteristics: impact, tensile, and yield strength, and hardness, improved as much as 100% over the same alloys cast by other methods. Asarcon® 773 (SAE 660), general purpose bearing bronze, is immediately available from stock in 260 sizes, rods and tubes in ½″ to 9″ diameters, lengths up to 105″. Special shapes can be made to order. Write: Continuous-Cast Products Dept., American Smelting and Refining Company, Barber, N. J., Kingwell Bros., Ltd., 457 Minna St., San Francisco. In Canada: Federated Metals Canada, Ltd., Toronto and Montreal.

CONTINUOUS-CAST DEPARTMENT OF

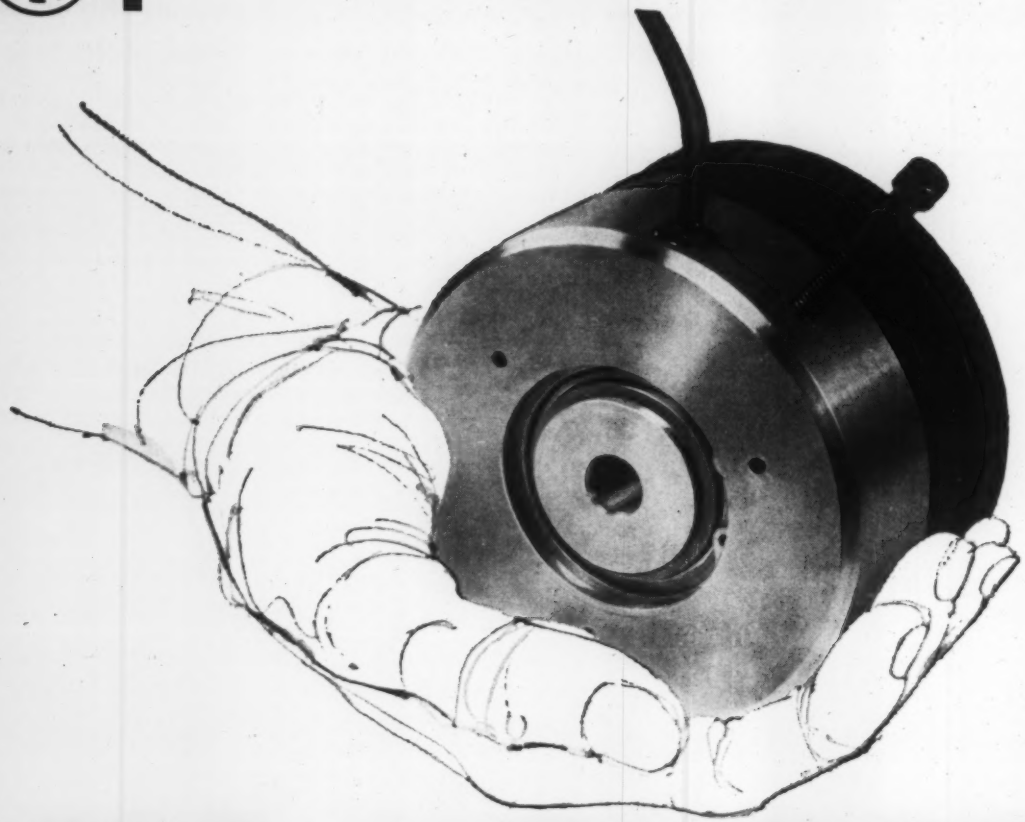


ASARCO

AMERICAN SMELTING AND REFINING COMPANY

58-17

I-T-E CIRCUIT BREAKER COMPANY



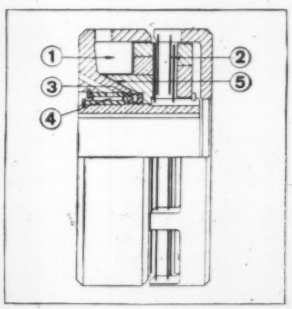
NO UPKEEP

New I-T-E Electro-Clutch with stationary field never needs maintenance of any kind!

In addition to greater compactness than any other clutch, now the I-T-E Electro-Clutch* is available with a tremendous new advantage: no upkeep. This new design has a stationary field that does away with the slipring and brush. So you are forever relieved of the problem of cleaning or replacing brushes. And of course there never was any other maintenance required . . . no air gap adjustments or friction surfaces to replace.

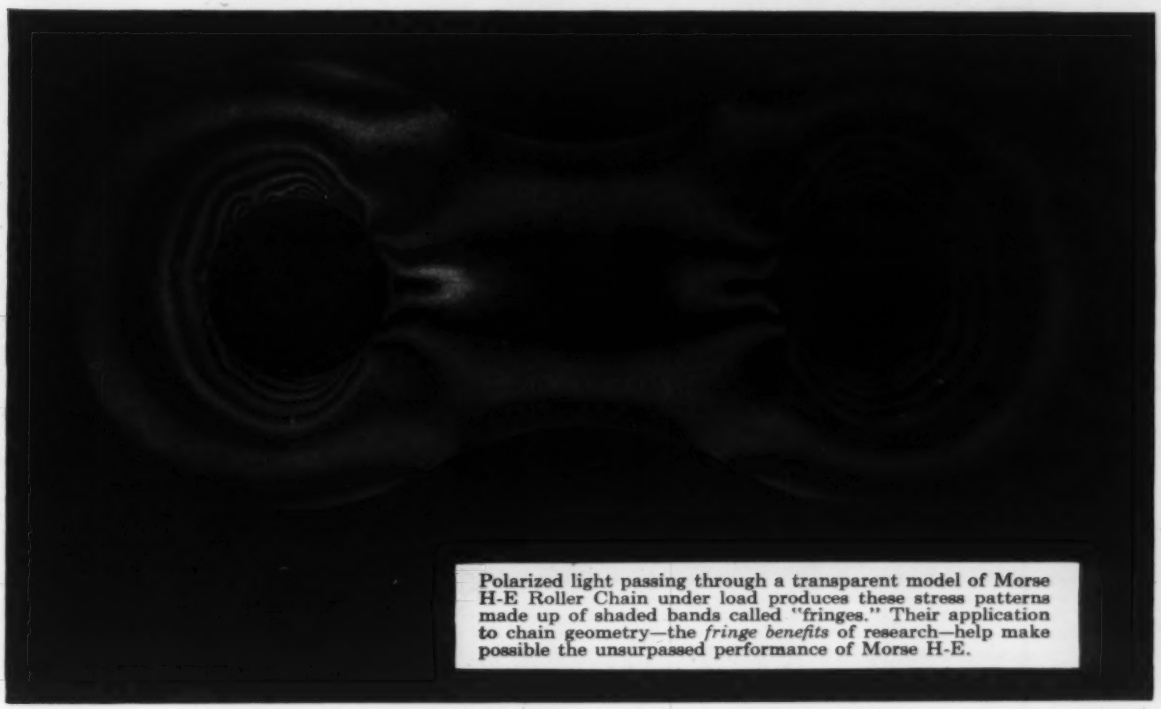
Elimination of upkeep means designers can bury the I-T-E Electro-Clutch inside a drive box or transmission . . . for access is never needed. It's a component that can be installed and practically forgotten. Roller thrust and needle radial bearings keep friction down and clutch size to a minimum . . . plus insuring long, efficient life.

Installation during machine assembly is simpler too. The clutch is delivered completely assembled. You merely slide it onto the shaft. This new I-T-E Electro-Clutch is made entirely in this country. So you are assured of availability. Same wide range of torque ratings as slipring models. Stock ratings are for 24 or 90 volts d-c. Other control voltages provided on request.



Cutaway view shows these details: (1) stationary coil windings that generate the field; (2) hardened steel clutch laminations that operate in an oily atmosphere and maintain constant torque rating without adjustments throughout life; (3) roller thrust bearings; (4) needle radial bearings; (5) air gap that never needs adjusting.

*PATENTS APPLIED FOR



Polarized light passing through a transparent model of Morse H-E Roller Chain under load produces these stress patterns made up of shaded bands called "fringes." Their application to chain geometry—the *fringe benefits* of research—help make possible the unsurpassed performance of Morse H-E.

Photoelastic stress study shows . . .

"FRINGE" BENEFITS MAKE MORSE H-E CHAIN LAST UP TO 5 TIMES LONGER!

Improved design . . . special mechanical and metallurgical processes give Morse H-E a 95% higher endurance limit

"Fringes"—the shaded bands which make up photoelastic patterns—show the intensity and distribution of stresses set up in a chain link-plate model under load. Morse engineers first use this knowledge to improve chain geometry. Then Morse production engineers apply advanced mechanical and metallurgical processes to side plates. Result: Morse High-Endurance Roller Chain, with up to 500% longer life under repeated heavy loadings.

Special treatment makes Morse H-E Chain cost about 10% more. Yet it pays for itself many times over in annual savings on replacement costs, lost production time and wasted man-hours.

For full information on research-developed Morse High-Endurance Roller Chain, write: Morse Chain Company, Dept. 6-49, Ithaca, N. Y. Export Sales: Borg-Warner International, Chicago 3, Ill. In Canada: Morse Chain of Canada, Ltd., Simcoe, Ont.

ORDINARY CHAIN BREAKS when the side plate tires from repetitive loading and unloading during the cycle around the sprockets. But Morse H-E Roller Chain has a 95% higher endurance limit . . . outlasts ordinary chain by up to 5 to 1 under repeated loading.

Visit the Morse Chain Booth 217 Design Engineering Show May 25-28

MORSE

MORSE B-W BORG-WARNER

*Trademark

A BORG-WARNER INDUSTRY

ONLY MORSE OFFERS ALL FOUR: Roller Chain, Silent Chain, Hy-Vo® and "Timing"® Belts

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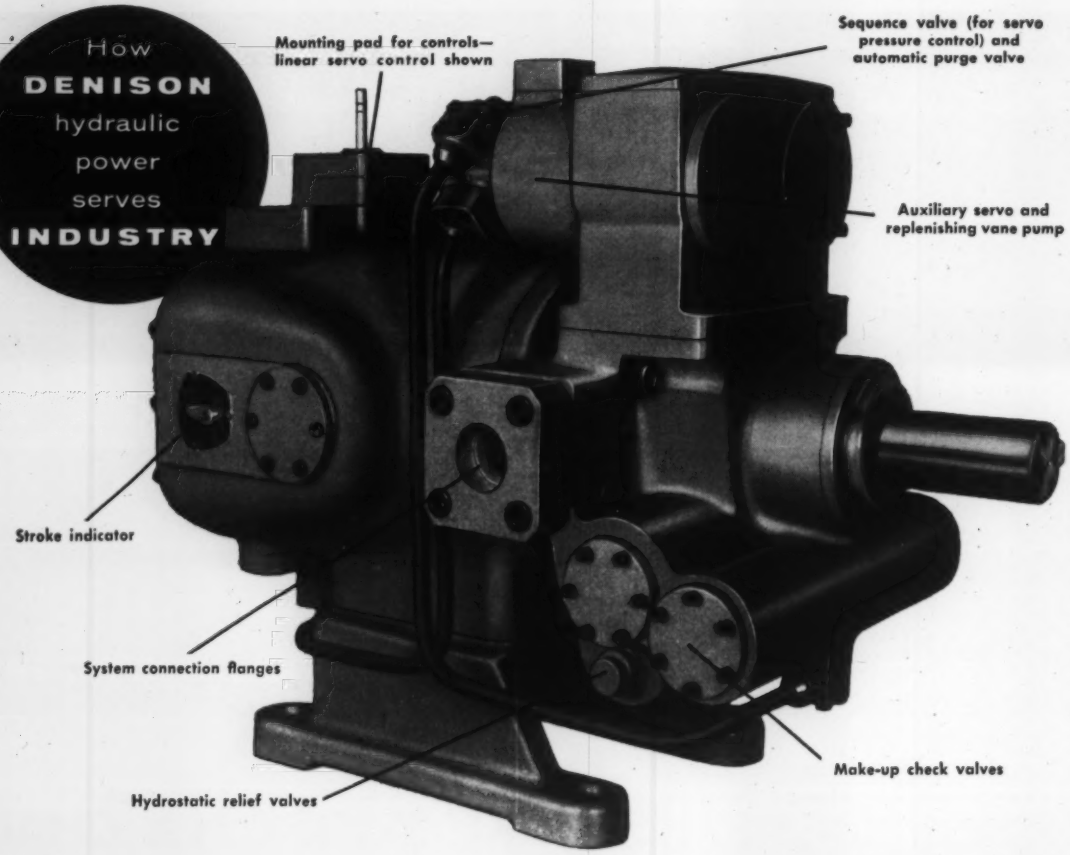
How DENISON hydraulic power serves INDUSTRY


Mounting pad for controls—linear servo control shown
Sequence valve (for servo pressure control) and automatic purge valve
Auxiliary servo and replenishing vane pump
Stroke indicator
System connection flanges
Hydrostatic relief valves
Make-up check valves

AXIAL PISTON PUMPS and MOTORS

For precision, split-second control of speed... torque... reversal... acceleration... deceleration

Series 30, 40 and 60

Constant and Variable Volume Pumps to 115 gpm
Fluid Motors to 373 inch-pounds per 100 psi
...for continuous service up to 3500 or 5000 psi

Denison's heavy-duty line of hydraulic Axial Piston Pumps and Motors offers important features and performance characteristics unexcelled in the hydraulic equipment field.

These Variable Volume Pumps are available as pre-built packages with built-in replenishing pump that provides supercharging . . . pressure control and forced circulation for cooling . . . plus relief and replenishing valves.

Axial Piston Pumps and Fluid Motors by Denison assure the kind of smooth, split-second, dependable operation required in today's most modern systems.

APPLICATIONS — Presses . . . transmissions . . . marine drives . . . missile ground support and handling equipment.

SPECIFICATION DATA

SERIES 30	SERIES 40
Constant and Variable Volume Pumps	**Constant and Variable Volume Pumps**
1200 rpm 3500 psi delivers 38 gpm	1200 rpm 3500 psi delivers 55 gpm
Fluid Motors	**Fluid Motors**
Torque—123.6 inch-pounds per 100 psi	Torque—179.7 inch-pounds per 100 psi

SERIES 60

Constant and Variable Volume Pumps
1200 rpm — 3500 psi delivers 115 gpm
Fluid Motors
Torque — 373 inch-pounds per 100 psi

OPERATING EFFICIENCY — Over-all mechanical efficiency at full load — 92%, Volumetric efficiency — 96%.

Other models for 5000 psi duty are available

Write for detailed Bulletins

DENISON ENGINEERING DIVISION
American Brake Shoe Co.
1240 Dublin Road • Columbus 16, Ohio

Denison Stocking Branch Offices: LOS ANGELES • CHICAGO
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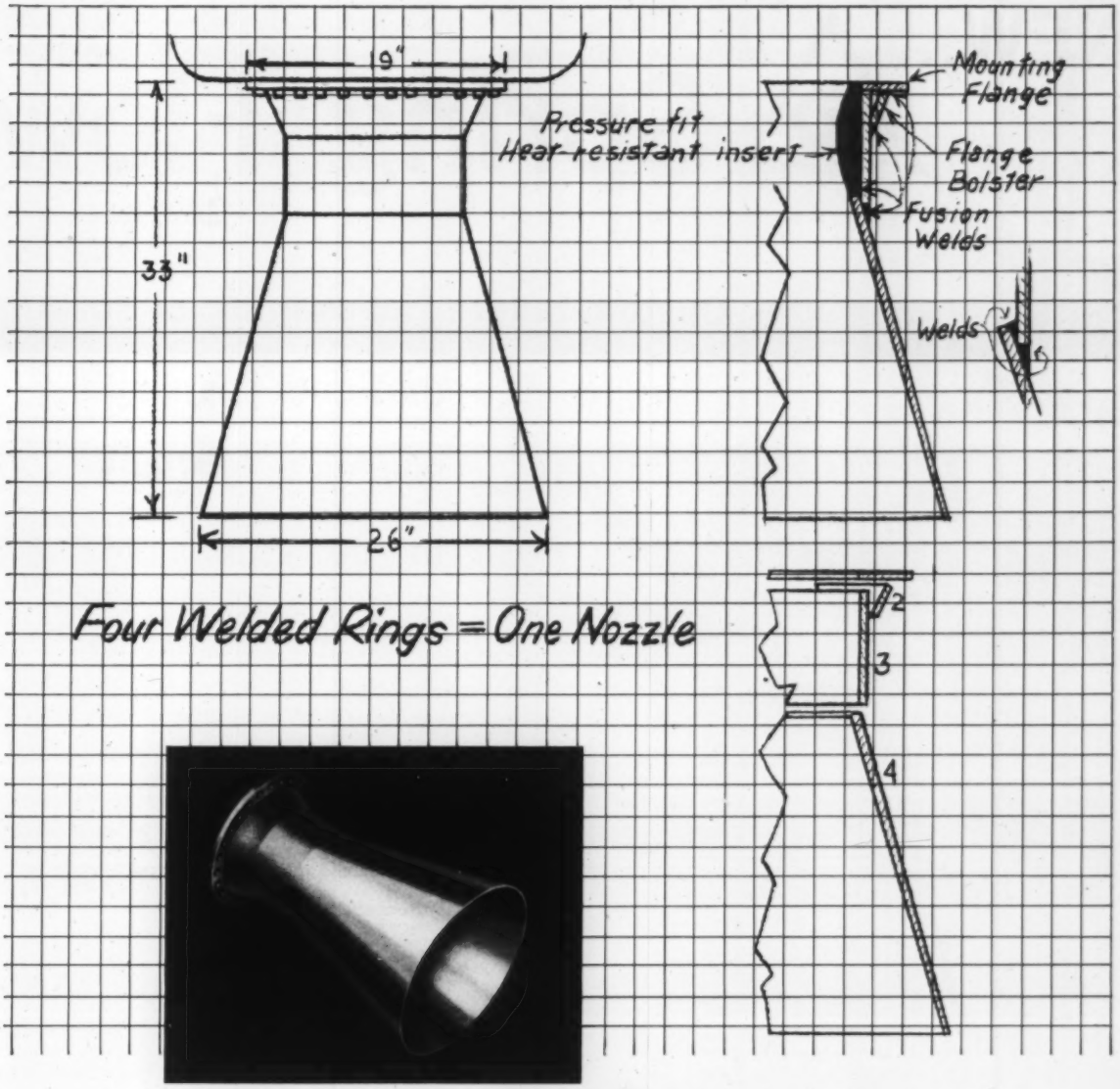
DENISON HydrOILics

HYDRAULIC PRESSES
PUMPS • MOTORS • CONTROLS

Circle 463 on Page 19



Nozzle cone for 100,000 lb. thrust is a WELDED RING ASSEMBLY with refractory insert

A booster rocket delivers a 100,000 lb. thrust. The nozzle cone—which takes this tremendous punch—is a welded assembly. Amweld engineers, working with a prime contractor, developed a method that simplified the fabrication of this vital part and reduced the cost.

The conical section is rough formed from a single piece of plate, welded, and circular formed. Other sections are torch cut from plate, formed, and welded together to form the completed assembly. After heat treating and machining, a graphite insert is fitted inside the nozzle cylinder.

Delivered at a considerable savings in fabricating and material costs, this Amweld welded assembly meets all requirements for this critical application.

This typical Amweld fabrication by welding can save you time and money. If you would like to know more about Amweld's prototype and production facilities, phone or write.

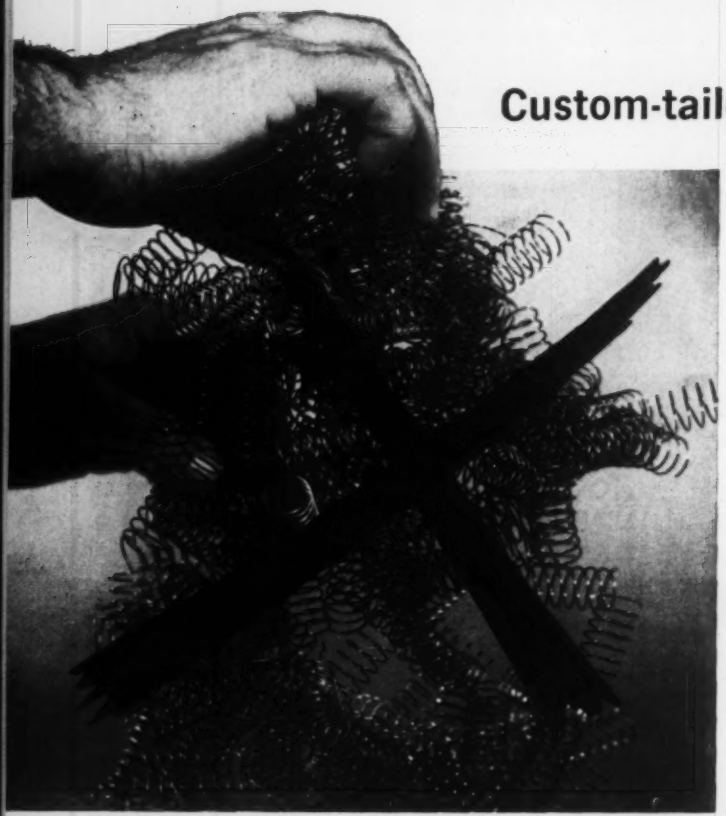
GET THE FACTS ABOUT AMERICAN WELDING

Complete information. Facilities brochure, Precision Assemblies Catalog, and booklet on "How Flash Butt-Welded Rings are Made."

THE AMERICAN WELDING & MFG. CO. • 130 DIETZ ROAD • WARREN, OHIO

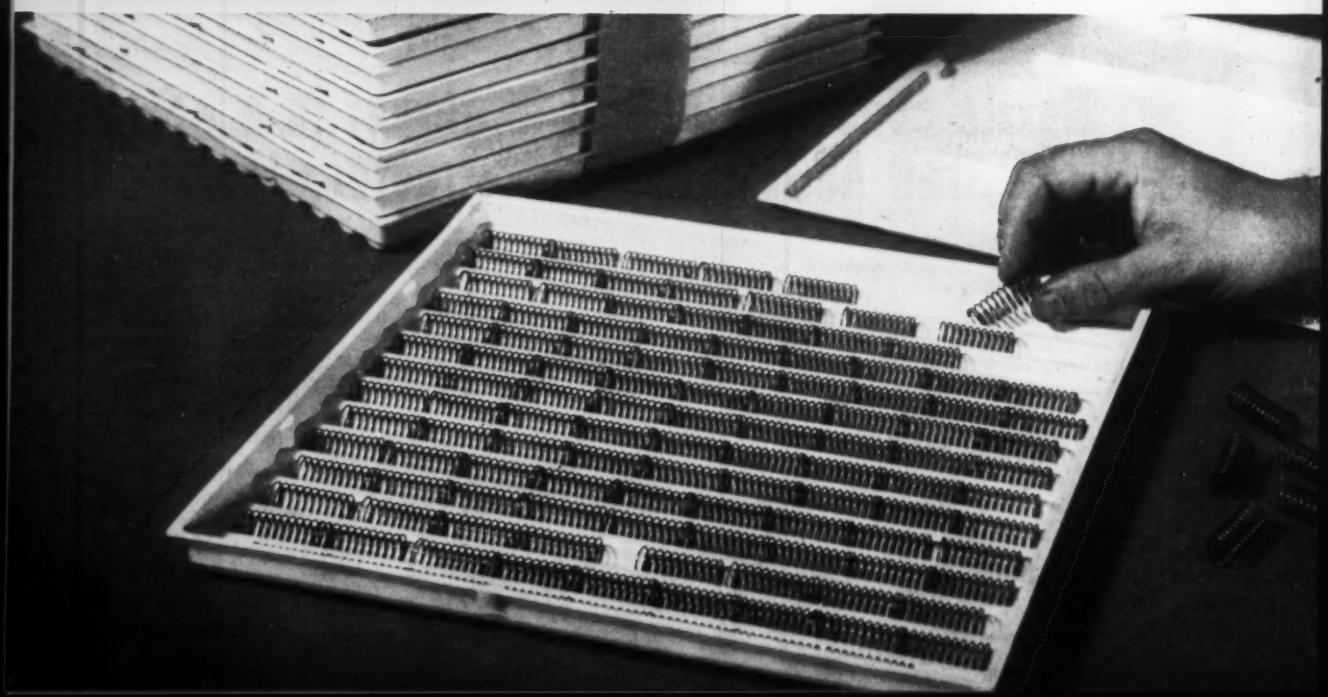
AMERICAN WELDING

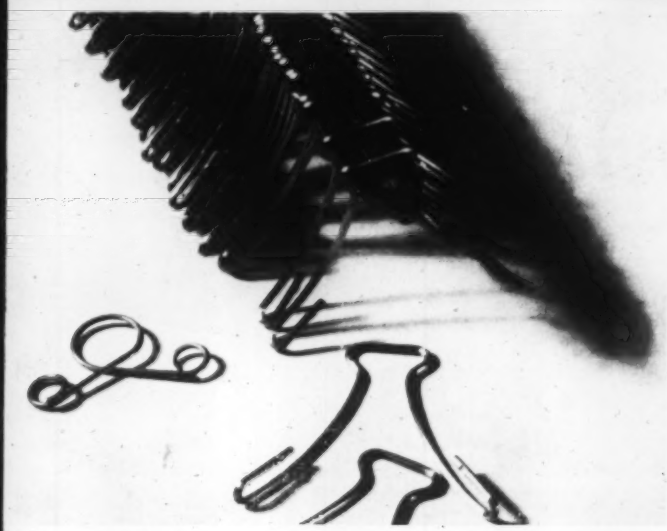
NEW... Spring Flow®

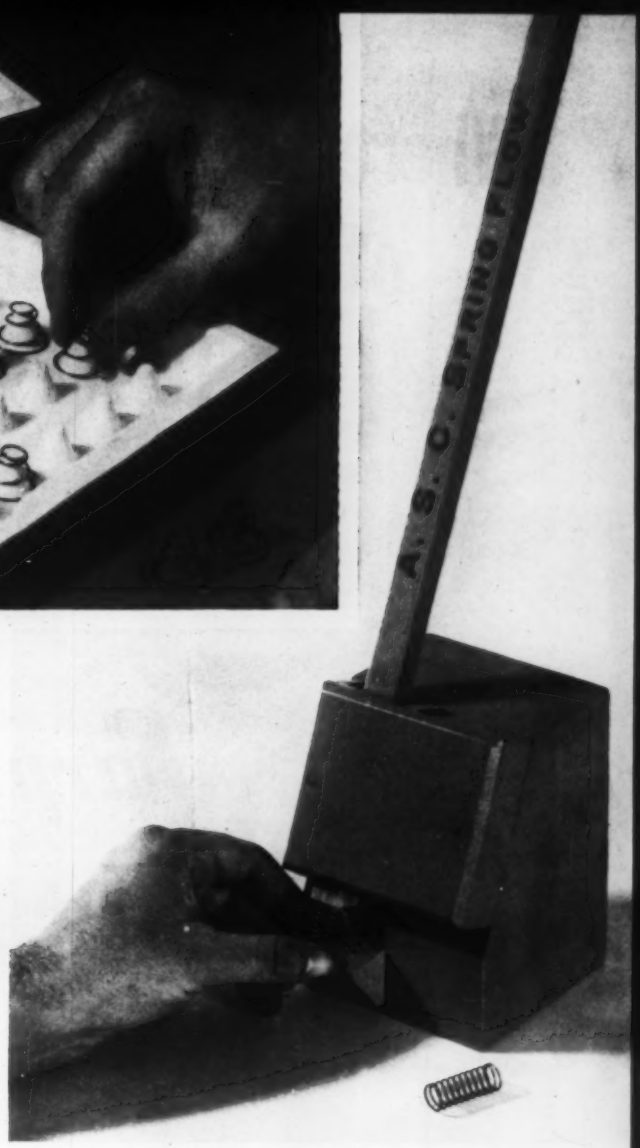


Custom-tailored packaging of springs that cuts costs and speeds operations in your plant

Spring Flow is a systematic approach to the problems of handling and storage of springs, wire forms, small stampings, in customer plants. It overcomes time-wasting tangling, and the distortion that often results from tangling. It can be engineered for specific applications to expedite hand or automatic assembly.







Spring Flow lowers handling and assembly costs — eliminates distortion — protects finish

Spring Flow makes use of a variety of modern materials, dispensers, containers. The extent to which it may be applied depends on the complexity of each individual part and handling requirements. The cost of Spring Flow is frequently offset by resulting savings.

The potential benefits of Spring Flow almost defy imagination. Ask for a Spring Flow proposal for your springs or other fabricated-metal products. Or find out more about this exclusive service by writing for the new booklet—"Spring Flow."

Associated Spring Corporation

General Offices: Bristol, Connecticut

Wallace Barnes Division, Bristol, Conn. and Syracuse, N. Y.
B-G-R Division, Plymouth and Ann Arbor, Mich.
Gibson Division, Chicago 14, Ill.
Milwaukee Division, Milwaukee, Wis.
Raymond Manufacturing Division, Corry, Penna.
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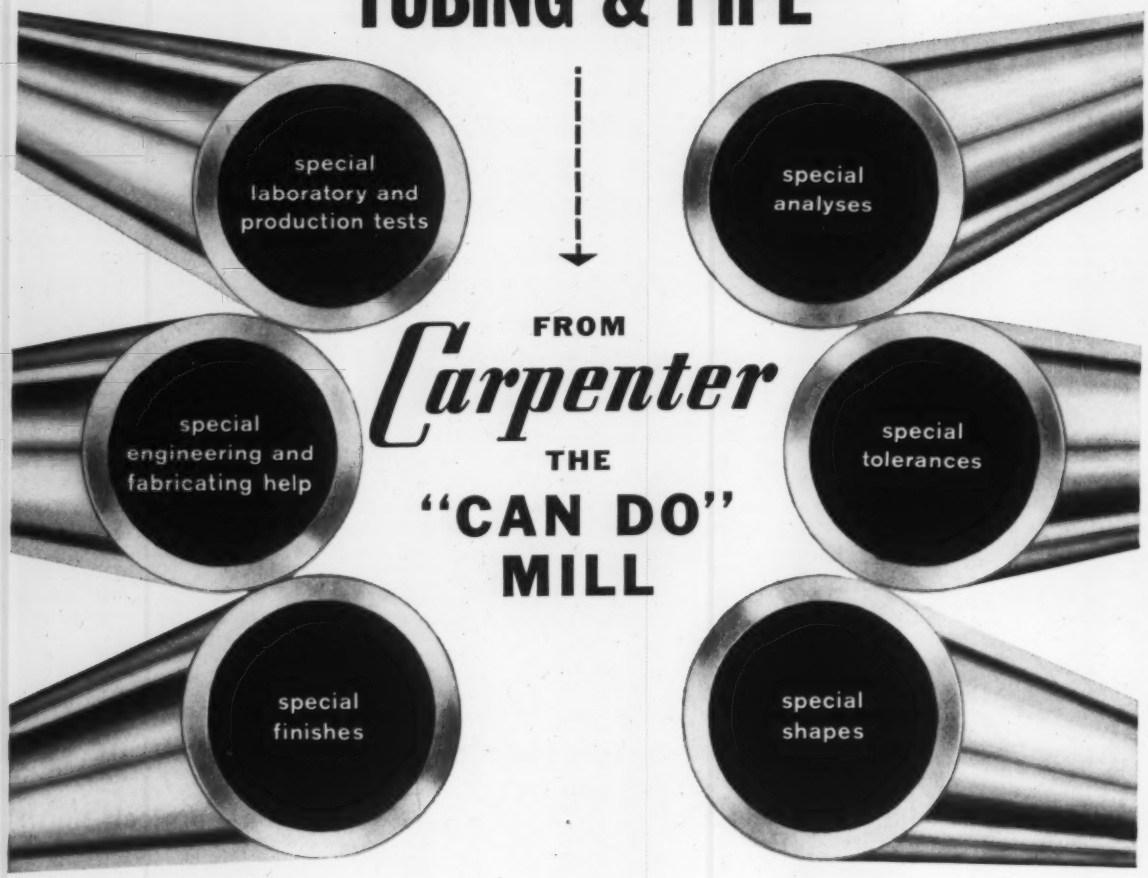
San Francisco Sales Office, Saratoga, Calif.
Seaboard Pacific Division, Gardena, Calif.
Cleveland Sales Office, Cleveland, Ohio
Dunbar Brothers Division, Bristol, Conn.
Wallace Barnes Steel Division, Bristol, Conn.

Canadian Subsidiary: Wallace Barnes Co., Ltd., Hamilton, Ont. and Montreal, Que. Puerto Rican Subsidiary: Associated Spring of Puerto Rico, Inc., Carolina, P.R.

Circle 465 on Page 19

5908

Where to get your "special needs" of Stainless and High Alloy TUBING & PIPE



Anytime you come up against *unusual* needs for stainless or high alloy tubing and pipe . . . anytime you are faced with hard-to-solve problems of corrosion, temperature conditions, fabrication, installation and design-engineering . . . it's time for you to consult with Carpenter. Save yourself time, worry and money by putting your "special needs" in our competent and experienced hands. Carpenter facilities and technical staff are geared to give you specialty services not available from other sources. Supplying plant engineers, equipment builders and product designers with the tubing, pipe and "know-how" to satisfy out-of-the-ordinary needs is a 32-year-old story with the Carpenter Alloy Tube Division. Whether your future needs are special or just ordinary, call in your Carpenter representative or contact The Carpenter Steel Company, Alloy Tube Division, Union, N. J.

your master key to cost-saving corrosion control

Carpenter

Stainless & High Alloy Tubing & Pipe

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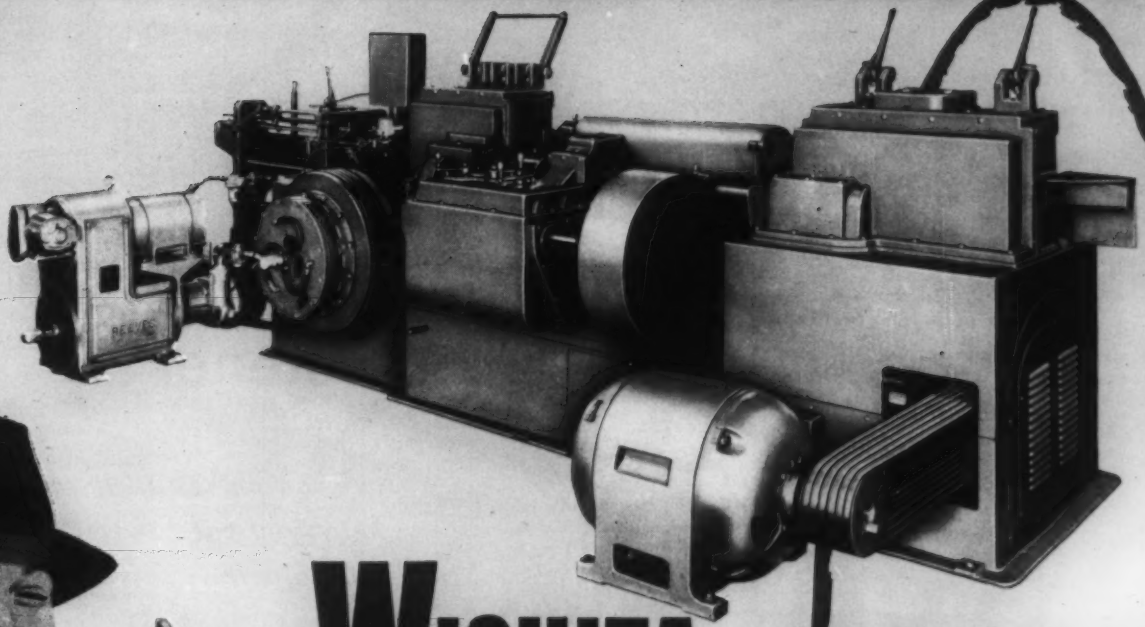
Circle 467 on Page 19→



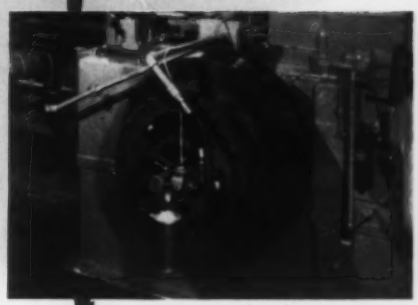
WICHITA

CLUTCHES AND BRAKES MEAN

Better Quality Control

on Lewis Automatic Wire Straightening and Cutting Machines!

"After making a study of available air clutches and brakes we decided on Wichita for several reasons," states F. J. Rybak, Vice President of The Lewis Machine Co., Cleveland, Ohio. "We found that Wichita Units provided the main features needed to improve quality – smooth, fast engagement due to low air consumption. Higher flywheel speeds are thus possible and by utilizing a Variable Speed Drive, we can perfectly synchronize our cut-off speed with the wire feed. We have also incorporated a Wichita Air-Tube Brake to eliminate the conventional drag brake which unnecessarily loaded the machine. In consequence, this Wichita Clutch and Brake System gives our machines BETTER QUALITY CONTROL. Now it is possible to produce perfectly straightened and accurately cut rod without "spot swell" which has long been a problem in the wire industry."



Close-up of Wichita Clutch mounted at rear of Lewis No. 11-F Travel Cut.

Wichita Low Inertia Air-Set Disc Brake.

Wichita Low Inertia Air-Tube Disc Clutch.

Take your START and STOP problems to a Wichita Engineer for the right answer!

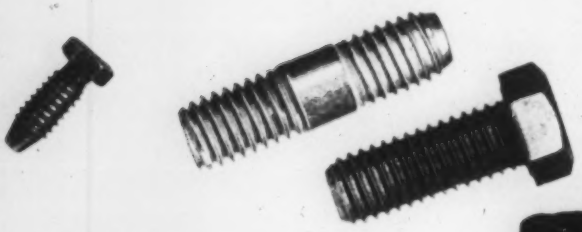
WICHITA Clutch COMPANY, INC.
WICHITA FALLS, TEXAS, U.S.A.

Contact your nearest Wichita Engineer!

Brehm-Lahner, Inc., Detroit, Michigan
L. H. Fremont, Cincinnati, Ohio
W. G. Kerr Company, Pittsburgh, Pa.
Smith-Keser & Co., Avon, Conn., Philadelphia 44, Pa., and New York, N. Y.
Frank W. Yarline Co., Chicago, Illinois
Larry W. McDowell, Long Beach, California
Andrew T. Lobel, Denver, Colorado
Robert R. King Co., Cleveland, Ohio
Norman Williams, Houston, Texas
Allied Transmission Equipment Co., Kansas City 8, Missouri
Donald E. Harman, Dallas, Texas
C. Arthur Weaver, Richmond, Virginia
Malcolm S. Cone, Memphis, Tennessee
Dominion Power Press Equipment, Ltd., Burlington, Ontario, Canada
R. E. Kunz, Seattle 4, Wash.
Norman Rupp Co., Portland 4, Ore.
Bates Sales Co., St. Louis 1, Mo.

NYLOK FASTENERS lock and seal by means of a tough nylon pellet embedded in the body of the fastener. Locking and sealing action is sustained, because the nylon attempts to return to its original shape when deformed. Nylok fasteners make excellent adjustment screws, oil pan and gear case bolts.

LOK-THRED meets conditions of severe vibration, tension, torsion, thermal loading. Lok-Threds can never back out, fret or shake loose. Because of its unique reforming and intimate metal to metal contact, Lok-Thred seals effectively in practically all metals. Widely used on engines and motors of all sizes and types.



PLACE BOLTS have a built-in spring action in the head of the bolt. This provides a safety margin of additional elastic elongation, and greatly reduces danger of fatigue failure in addition to locking. Place Bolts can be used wherever Cap Screws are used, and effect real savings in most applications.

Which self-locking fastener?

Lamson makes all three, helps you cut costs, not corners

Nylok. Lok-Thred. Place Bolt. All are variations on the same theme. However, one of the three will be better suited to your application. One will lower your assembly cost more than the other two. Which one?

Because Lamson makes all three self-locking fasteners . . . standards and specials . . . Lamson engineers are anxious (and able) to recommend the one that's best for you. That helps you make a better product. That helps you cut costs... not corners. Contact a Lamson Sales Engineer for details.

SEND FOR ENGINEERING DATA

Gentleman: Mail engineering data on Place Bolts ☐ Lok-Thred ☐ Nylok ☐

Have nearest Sales Engineer call for appointment ☐

Application we're considering is _____

_____

Name _____

Company _____

Street _____

City _____ State _____

LAMSON & SESSIONS

5000 TIEDEMAN ROAD • CLEVELAND 9, OHIO

Plants in Cleveland and Kent, Ohio • Chicago and Birmingham

Circle 468 on Page 19

MACHINE DESIGN

April 30, 1959

Keeping Ahead

SOMEBODY — it might have been Mark Twain—once observed that there is little difference between those who don't read and those who can't. Universal education has not wiped out illiteracy.

Engineers are taught to learn from books and periodicals. But how many really appreciate the resources waiting to be tapped in scientific and engineering publications? And how many company managements recognize the value of easy access to engineering literature?

Engineers read technical material for two reasons. They want to build up their own mental equipment or they seek solutions to current practical problems. The distinction is important.

Reading for self-improvement is a personal responsibility. It increases an engineer's value to his company. The incentive is the prospect of ultimate salary improvement. And so the engineer who hopes to get ahead must expect to do much of this sort of reading on his own time.

Reading for the answers to problems is another matter. The wise company invests generously in library space, in adequate stocks of books and periodicals pertinent to its field, and in trained staff to help engineers obtain access to the information they need.

Such investment pays off handsomely in conserving engineering time. It also gives some assurance that the engineers have not neglected alternative answers that might improve a design or save some cost.

Occasionally a penny-pinching management has been known to deny circulation of current engineering periodicals in its own research, development, and engineering organization. Such a policy imposes a needless handicap on the company's prospects of keeping ahead of competition. It discourages the prompt use by engineers of essential engineering tools.

The vital new ideas, techniques, and information that engineering periodicals bring in a steady stream from the outside are part of the lifeblood of a creative organization. Farseeing management makes darned sure that this revitalizing flow gets to the engineers who can use it—fast.

Colin Carmichael

EDITOR

Surveys (Technical, industrial)

Directories (Technical, professional, trade)

Standards (ASA, ASTM, society, government)

Specifications (Commercial, defense)

Codes (Municipal, state, national)

Are most of these references available *somewhere* in your organization? Chances are, they'll be a lot more useful if centralized in an engineering library.

Magazines and Periodicals

Books and pamphlets

Indexes of periodicals

Manufacturers' catalogs

Dictionaries and encyclopedias (General, special)

Government publications (U. S., foreign, joint)

Society proceedings

University brochures

Telephone directories (out-city, out-state)

Maps and city directories

The Case for

STARTING

GLORIA EVANS
Engineering Librarian
Parke, Davis & Co.
Detroit, Mich.

Less than 300 years ago, it was possible to read all significant literature in any technical field. Not so today! Annual production of technical literature today is about 60 million pages. At this rate, what chance have engineers to keep posted even with portions of their fields? The answer is: Pretty good—if they have ready access to an engineering library.

AN ENGINEERING LIBRARY

TECHNICAL libraries are growing rapidly both in number and importance. Engineering departments, particularly, can function better when special information they need is organized and close at hand. Once established, regardless of size, special libraries soon become valuable services.

Starting an engineering library is not a big job. Most engineers have the nucleus of a library in their own files. These random collections soon grow to occupy valuable space and sometimes cause duplication. At this point, a regular library merits consideration.

What a Library Does

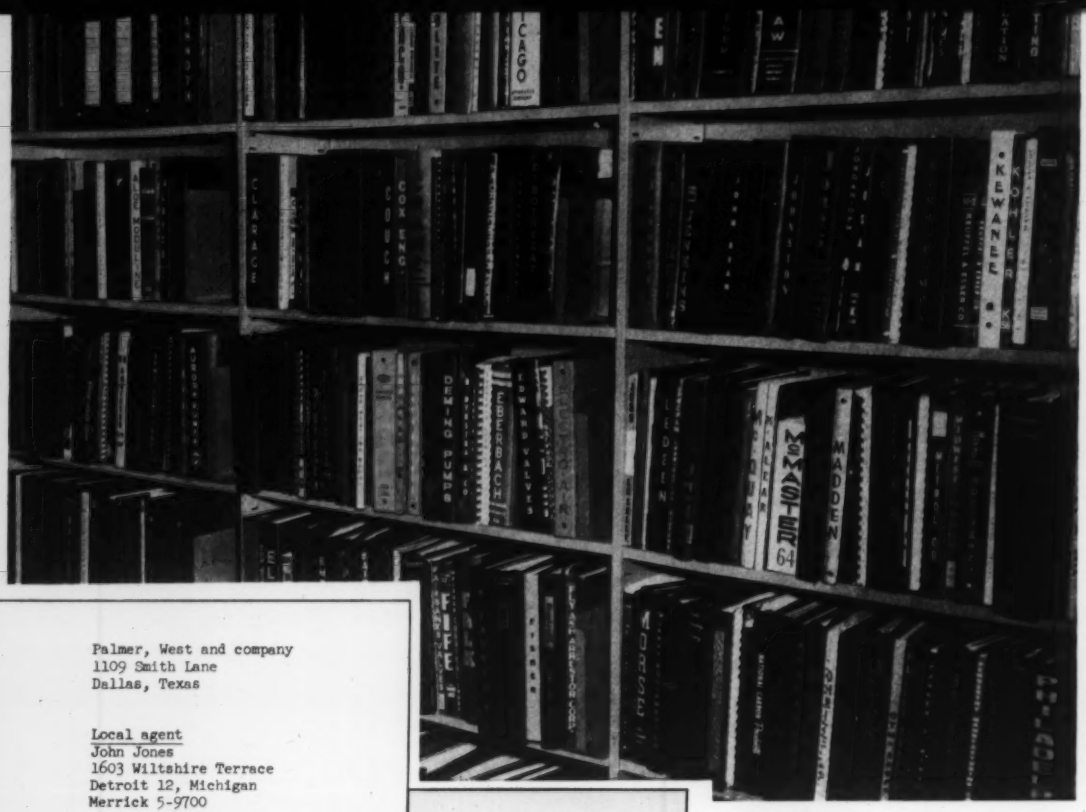
By acting as a clearing house for all kinds of literature, and by providing a centralized source of books, pamphlets, and periodical subscriptions, a library prevents wasteful duplication. Organized literature, widely varied in content and physical form, and special reference services are a library's stock-in-trade.

Trade Literature: In an organized library, bulky catalogs can be shelved like books, in alphabetical order. Loose material is filed in sturdy folders. Venders' catalogs are checked for the manufacturers they represent. A card catalog can be cross-indexed by company name, tradename, local agent, and in some cases product name to tie the collection together. A quick check of the cards shows what companies are represented in the library and where their material is filed.

It's not much work to keep a trade literature collection up to date. Most salesmen are eager to supply their companies' latest editions. Superseded material is withdrawn as new issues arrive. If more detailed literature is needed for certain projects, a librarian might spare engineers the trouble of further search for sources and the paperwork involved.

Books and Pamphlets: Few engineers can afford the collections of books they'd like. But they'll find what they need, readily accessible, in an engineering library. If additional copies are needed, library circulation records can justify purchase. When a book is to serve a temporary purpose only, it is usually cheaper to borrow than buy. Every new book and pamphlet is examined by the library for content of particular interest to the engineers served. Appropriate entries can be added to the card catalog.

Magazines: No engineer can afford to ignore the periodical journals in his field. At best, however, his reading time is limited. Here, a library can improve reading efficiency by tailoring the routing of



Palmer, West and company
1109 Smith Lane
Dallas, Texas

Local agent
John Jones
1603 Wiltshire Terrace
Detroit 12, Michigan
Merrick 5-9700

INSULATION

See

Trade literature files, Smith, John & son

ELECTRIC SYMBOLS

Graphical symbols for architectural plans, power, and control. In: Electrical construction and maintenance 57:6-8 mid-S'58.

MICROFILM

For additional material, contact:

National Microfilm Association
P. O. Box 386
Annapolis, Md.

Representative entries in library card catalog, including references to trade literature.

magazines to the needs of its patrons.

Temporary interests and changes in long-term assignments are accommodated the same way. A library also routes new publications for technical appraisal. Back issues of magazines are stored for reference. Standard periodical indexes, supplemented by a librarian's indexing based on company interests, are excellent sources of information.

Reference Service: Retrieval of technical information is a fast-growing problem for engineers, but there are many ways an organized library can help. A good reference library is like a detective bureau. Sometimes it produces an answer in minutes, while other queries take hours of research.

No matter how large and complete a library may be, eventually it must borrow from other libraries. Libraries grant loans to other libraries, which they would not grant to individuals, because both parties know that regular library practices are observed throughout the transaction. These outside sources include other special libraries, public libraries, university libraries, government agencies, and trade and professional associations. Many of these sources also lend films and film strips. Active liaison yields regular notices of their publications and announcements of important events.

How to Get Started

Initially, arrangements should be made to buy or transfer such basic equipment as filing cabinets, shelving, a card catalog, desk, worktable, and chairs.

Later, the library should have its own budget and learn to live within it. A survey conducted in 1957 showed that total annual library budgets, exclusive of salaries, varied from $1000 to $20,000. Median was $5900. Library dollars per engineer varied from $3 to $152. Median was $40.50.* Quality, quantity, and range of services affect library budgets.

Selecting a library site is important too. A central location, close to patrons, is preferred. Even limited space can be used efficiently. One engineering library, serving about 600 engineering and maintenance personnel, occupies only 250 sq ft. This includes seating for three patrons, a librarian, and an assistant.

Choosing a Librarian: Do not assume that an office clerk or secretary, with occasional free time, can manage a library effectively. Demands on libraries soon require a professional person, trained in library skills. Two of the most important are: *Classification*, the systematic grouping of materials on shelves and files, and *cataloguing*, the written description of each item in a library.

The spirit of service must be particularly strong in a trained librarian, for all material received in a library must be scanned with patrons' interests in mind. This is not a static activity. Interests, assignments, and objectives change continually.

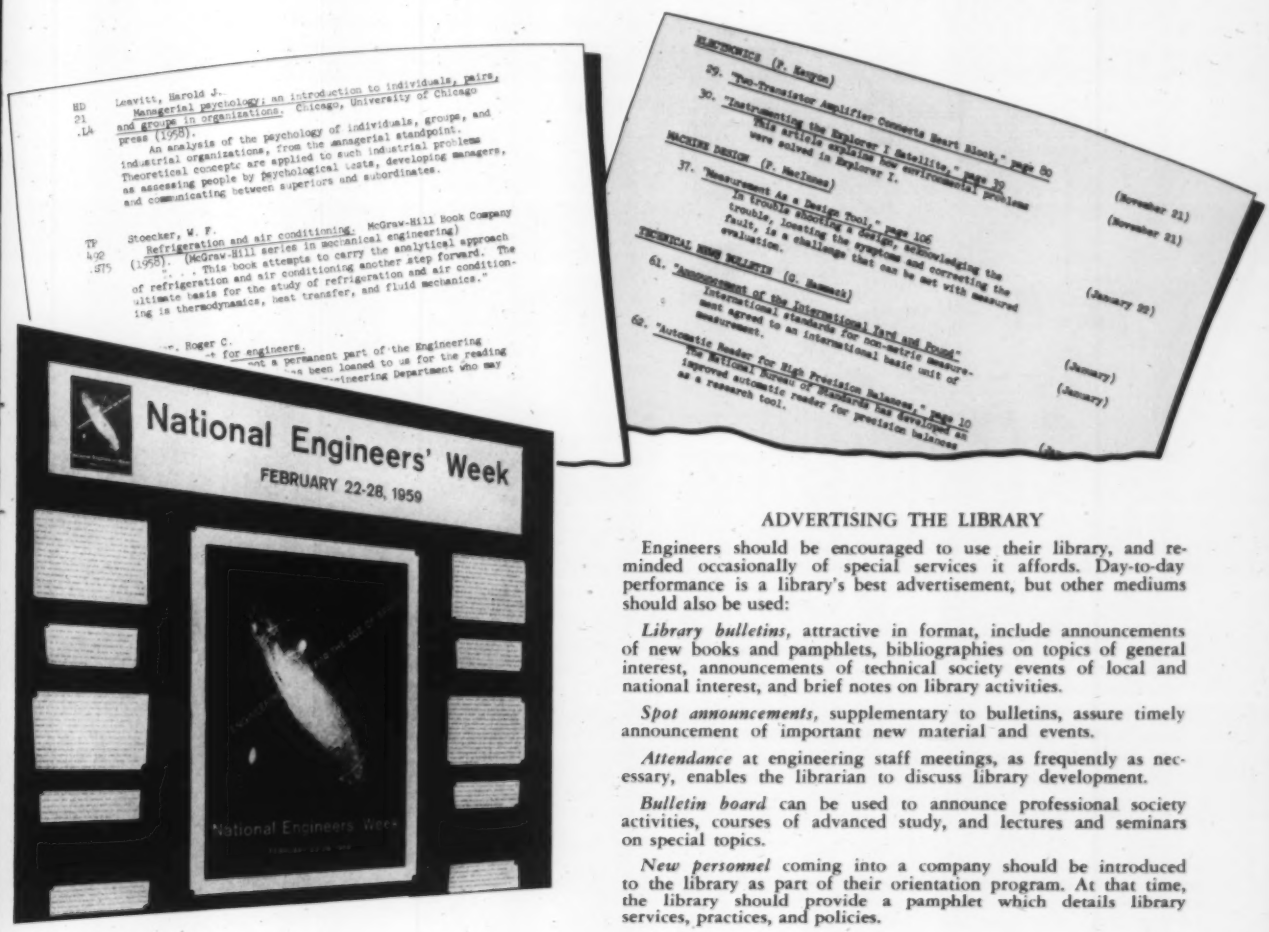
Certain technical files—usually not extensive but highly specialized—must remain with individual engineers. A librarian can give tips on organization to make this material more useful.

Getting Advice: The Consultation Service of the Special Libraries Association provides all kinds of organizations with competent advice on setting up, financing, expanding, reorganizing, or operating a special library or information service.

Chapters of SLA in the U. S. and Canada have active Consultation Committees which function like the national Consultation Service but in their own geographic areas. In response to requests for consultation, local committees can provide a competent librarian with an appropriate subject background. The consultant will discuss problems and developments, survey existing facilities, and offer recommendations (a written report, if desired). This service is free, except for travel expenses, but is limited to one day's time.

If a company requires more help than a single consultation, Association national headquarters can provide names of professional consultants experienced in special subject fields. As plans crystallize, SLA also makes its placement service available free.

*Eleanor B. Gibson—"Making a Library Survey", *Special Libraries*, Vol. 48, No. 4, April 1957, p. 137.


Leavitt, Harold J.
Managerial psychology; an introduction to individuals, pairs, and groups in organizations. Chicago, University of Chicago press (1958).
An analysis of the psychology of individuals, groups, and industrial organizations, from the managerial standpoint. Theoretical concepts are applied to such industrial problems as assessing people by psychological tests, developing managers, and communicating between superiors and subordinates.
Stoecker, W. F.
Refrigeration and air conditioning. McGraw-Hill Book Company (1958). (McGraw-Hill series in mechanical engineering)
. . . This book attempts to carry the analytical approach of refrigeration and air conditioning another step forward. The ultimate tests for the study of refrigeration and air conditioning is thermodynamics, heat transfer, and fluid mechanics."
ELECTRONICS (P. Keegan)
29. "Two-Transistor Amplifier Connects Heart Block," page 32
30. "Instrumenting the Explorer I Satellite," page 80
This article explains how environmental problems were solved in Explorer I.
MACHINE DESIGN (P. MacInnes)
37. "Measurement As a Design Tool," page 106
(November 21)
In trouble shooting a design, acknowledging the trouble, locating the symptom and correcting the fault, is a challenge that can be met with measured evaluation.
(November 21)
TECHNICAL NEWS BULLETIN (G. Hammack)
61. "Announcement of the International Yard and Pound"
International standards for non-metric measurement agreed to an international basis unit of measurement.
(January 22)
(January)
62. "Automatic Reader for High Precision Balances," page 10
The National Bureau of Standards has developed an improved automatic reader for precision balances as a research tool.
(January)
National Engineers' Week
FEBRUARY 22-28, 1959

ADVERTISING THE LIBRARY

Engineers should be encouraged to use their library, and reminded occasionally of special services it affords. Day-to-day performance is a library's best advertisement, but other mediums should also be used:

Library bulletins, attractive in format, include announcements of new books and pamphlets, bibliographies on topics of general interest, announcements of technical society events of local and national interest, and brief notes on library activities.

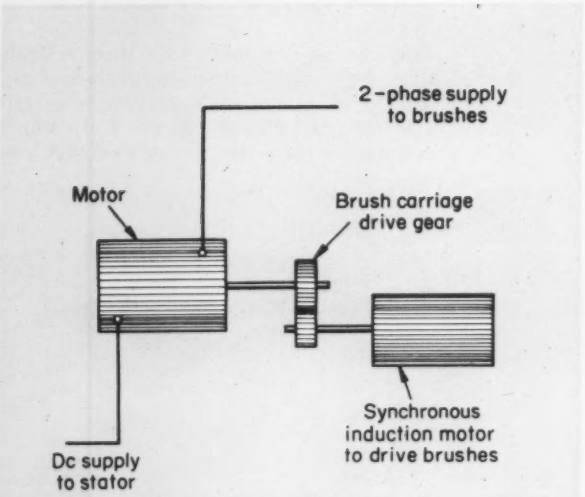
Spot announcements, supplementary to bulletins, assure timely announcement of important new material and events.

Attendance at engineering staff meetings, as frequently as necessary, enables the librarian to discuss library development.

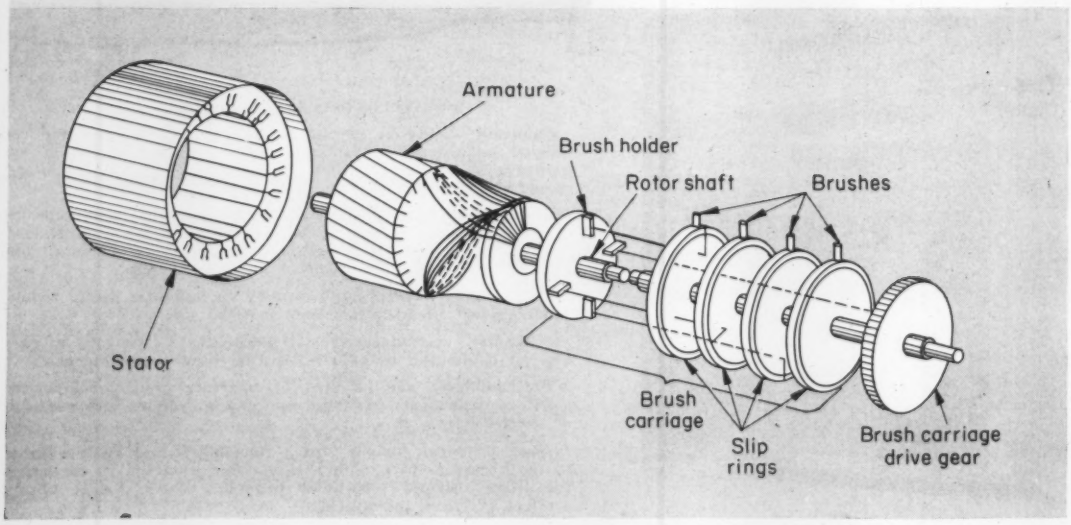
Bulletin board can be used to announce professional society activities, courses of advanced study, and lectures and seminars on special topics.

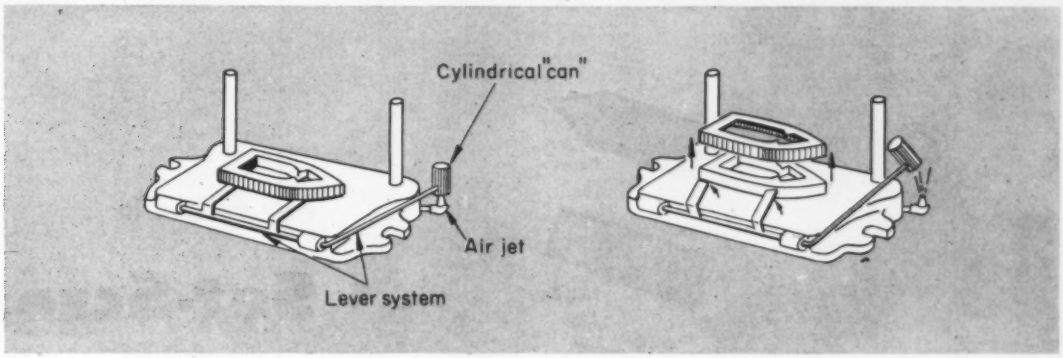
New personnel coming into a company should be introduced to the library as part of their orientation program. At that time, the library should provide a pamphlet which details library services, practices, and policies.

scanning the field for *ideas*



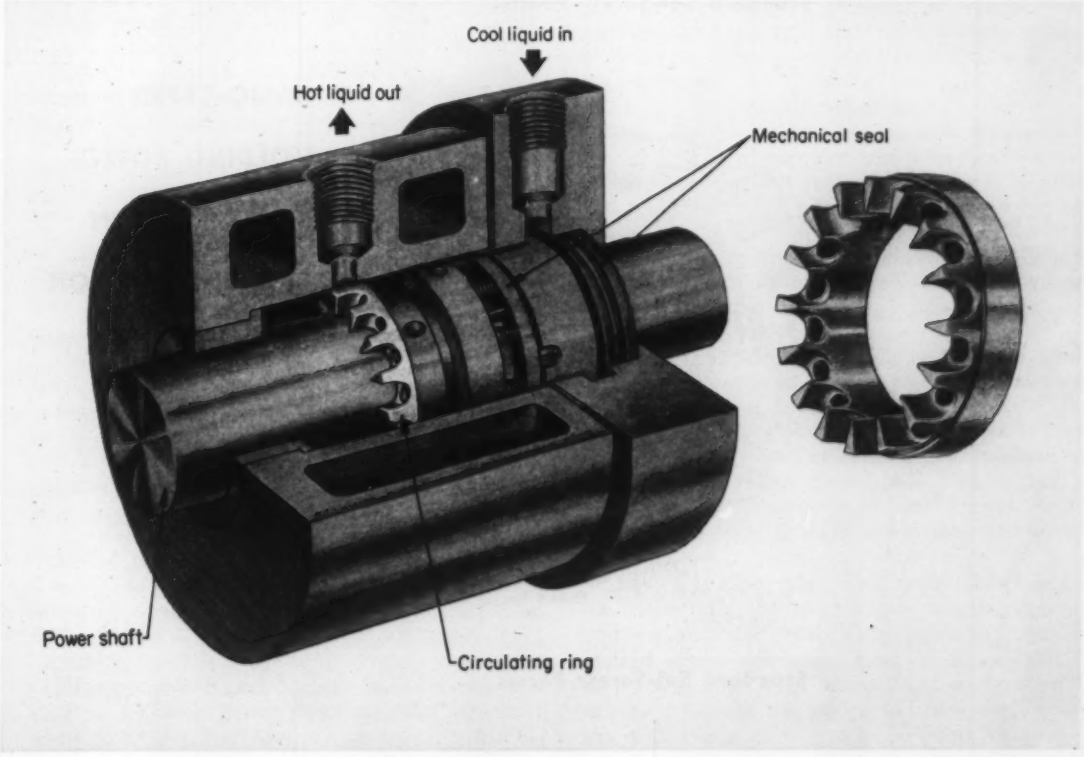
Adjustable-voltage control of ac motor permits wide range of speed variation with a high power-factor characteristic. In a design developed by Professor Paul A. Charlu of P.S.G. College of Technology (Coimbatore, South India), the ac-motor stator is excited with a dc voltage and the ac-motor "armature" is excited with a two-phase ac voltage through synchronously rotating brushes. Adjustment of the speed and power factor is accomplished by varying the dc field excitation or the ac voltage to the armature, or by advancing or retarding the revolving brushes.





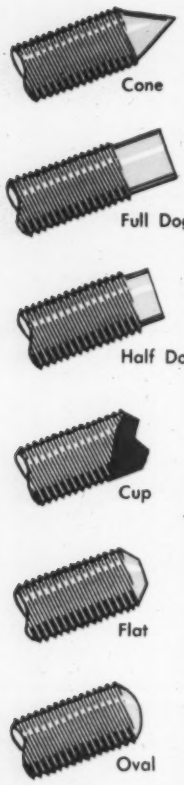
Air-actuated lever system permits remote control of machine operation when space limitations prohibit direct application of pneumatic forces. An air jet is directed into the open end of a cylindrical "can" attached to one end of a mechanical lever. Air pressure is converted to a lever force by the can and is transmitted to the operating point by the lever system. Reported in the *Power Press Safety Manual* of the National Safety Council, this principle is employed as a power press ejection device by Guide Lamp Div., General Motors.

Pumping ring in mechanical seal circulates cooling liquid to prevent seal wear and dry running. In a stuffing box seal developed by Durametallic Corp., a circular ring with vane-like protrusions is fastened to the power shaft. As the shaft rotates, the ring circulates the stuffing box liquid through the box and a heat exchanger to maintain an optimum operating temperature.

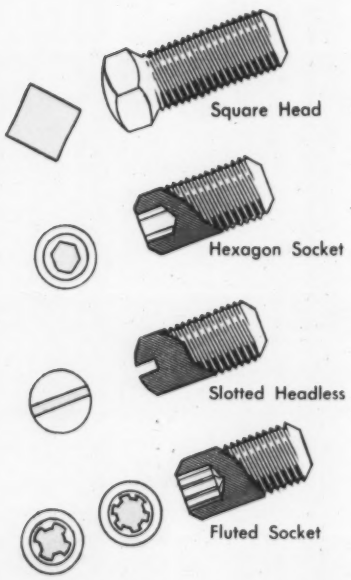


Key Factors in

Set-Screw



Standard Set-Screw Points



Standard Set-Screw Forms

- **BASIC TYPES**
- **HOLDING POWER**
- **SIZE SELECTION**
- **SCREW RETENTION**

Selection

FRANCIS R. KULL, Project Engineer, Standard Pressed Steel Co., Jenkintown, Pa.

CONVENTIONAL approach to set-screw selection is usually based on some rule-of-thumb procedure. Often, these methods will give satisfactory results, but their range of usefulness is limited.

In contrast to most fastening devices, the set screw is essentially a compression member. Forces developed by the screw point on tightening produce a strong clamping action that resists relative motion between assembled parts. Basic problem in design is to find the best combination of set-screw form, size, and point style that will provide the required holding power.

As a guide to design decisions, factors influencing selection, application and specification of standard set screws are summarized in this article. Only those applications where the set screw is the sole means of attachment are considered. However, the same concepts are equally valid in other assembly situations.

Standard Forms

Standard set-screw forms (ASA B18.62-1956 and ASA B18.3-1954) are shown in the title illustration. General details of these screw forms are summarized in the following sections.

Square Head: Standard range of sizes is No. 10 to 1½ in. Entire length of body is threaded. Standard threads are coarse, fine, or 8-thread series, Class 2A. Sizes ¼ in. and larger are normally available in coarse threads only.

Slotted Headless: Standard range of sizes is No. 5 to ¾ in., threaded the entire length of screw. Standard threads are coarse or fine-thread series, Class 2A.

Hexagon and Fluted Socket: Standard range of sizes is No. 5 to 2 in., threaded entire length of screw in 1/16-in. increments from ¼ to ⅝ in., ⅛-in. increments from ⅝ to 1 in., ¼-in. increments from 1 to 4 in., and ½-in. increments from 4 to 6 in. Standard threads are coarse or fine-thread series, Class 3A. For fluted-socket set screws, Nos. 0, 1, 2, 3, 5, and 6 have four flutes, Nos. 4, 8, and larger have six flutes.

Standard Points

Each of the standardized set-screw forms is available in any one of six point styles: Cup, cone, dog, half dog, flat, and oval. Selection of a specific point is influenced by functional, as well as other, considerations. General application features of each of these point styles are highlighted in the following discussion:

Cup: This point is by far the most widely used. It is employed when quick and permanent location of gears, collars, and pulleys on shafts is required, and when cutting-in action of the point is not objectionable. Heat-treated set screws of Rockwell C 45 hardness or greater can be used on shafts with surface hardness up to Rockwell C 35 without deforming the point.

Cone: This point is used in applications where permanent location of parts is required. Because of its penetration, it develops the greatest axial and torsional holding power. Where the point bears against material of Rockwell C 15 hardness or greater, it is usually spotted in a hole to half its length, so that penetration is large enough to develop ample shear strength across the cone section.

Dog: Of the two types of dog points, the half dog has more effective threads per length of screw and is more widely used. These points are normally applied where permanent location of one part in relation to another is desired, and are spotted in a hole drilled in the shaft. In these applications, the drilled hole must match the point diameter to

Table 1—Selection Data for Cup-Point Set Screws (Seated Against Steel Shaft with Hardness Rockwell C 15)

Nominal Screw Size	Seating Torque (lb-in.)	Axial Holding Power (lb)	Torsional Holding Power (lb-in.) for shaft diameter (in.) of																							
			1/8	3/16	1/4	5/16	3/8	7/16	1/2	9/16	5/8	11/16	3/4	13/16	7/8	1	1 1/4	1 1/2	1 3/4	2	2 1/2	3	3 1/2	4
No. 0	0.5	50	1.5	2.3	3.1	3.9	4.7	5.4	6.2																	
No. 1	1.5	65	2.0	3.0	4.0	5.0	6.1	7.1	8.1		10.0															
No. 2	1.5	85	2.6	4.0	5.3	6.6	8.0	9.3	10.6		13.2															
No. 3	5	120	3.2	5.6	7.5	9.3	11.3	13.0	15.0		18.7		22.5		26.3											
No. 4	5	160		7.5	10.0	12.5	15.0	17.5	20.0		25.0		30.0		35.0	40.0										
No. 5	9	200			12.5	15.6	18.7	21.8	25.0		31.2		37.5		43.7	50.0	56.2	62								
No. 6	9	250				19	23	27	31		39		47		55	62	70	78	94	109						
No. 8	20	385				30	36	42	48		60		72		84	96	108	120	144	168	192					
No. 10	33	540					51	59	68		84		101		118	135	152	169	202	236	270	338				
¼ in.	87	1000							125		156		187		218	250	281	312	375	437	500	625				
5/16 in.	165	1500									234		280		327	375	421	468	562	656	750	937	1125	1310	1500	
⅜ in.	290	2000											375		437	500	562	625	750	875	1000	1250	1500	1750	2000	
7/16 in.	430	2500													545	625	702	780	937	1095	1250	1560	1875	2210	2500	3125
½ in.	620	3000														750	843	937	1125	1310	1500	1875	2250	2620	3000	3750
9/16 in.	620	3500															985	1090	1310	1530	1750	2190	2620	3030	3500	4370
⅝ in.	1225	4000																1250	1560	1750	2000	2500	3000	3500	4000	5000
¾ in.	2125	5000																			1875	2190	2500	3125	3750	4375	5000	6250	7500	8750	10000
⅞ in.	5000	6000																				2620	3000	3750	4500	5250	6000	7500	9000	10500	12000
1 in.	7000	7000																					3500	4375	5250	6120	7000	8750	10500	12250	14000

prevent side play. Holding power is based on shear strength across the point. Occasionally these points are used in place of dowels and where the end of the thread must be protected. Dog points are recommended for use with hardened members and, also, on hollow tubing, provided some form of locking device is used to hold the screw in place.

Flat: When frequent resetting of one machine part in relation to another is required, flat points are a logical choice. They cause very little damage to the part against which the point of the screw bears. Hence, they are particularly suited for use against hardened steel shafts. This type of point can also be used as an adjusting screw for fine linear adjustments. For such applications, a flat is usually ground on the shaft for better point contact. Flat points are also preferred where wall thickness is thin or the containing component is made of any soft metal.

Oval: This point is used when frequent adjustment is necessary without excessive deformation of part against which it bears. Also, this point is used for seating against angular surfaces. Circular U-grooves or axial V-grooves are sometimes provided in the shaft to allow rotational or longitudinal adjustment. In other applications, the shaft is normally spotted to receive the point. However, the oval point has the lowest axial or torsional holding-power of all points.

Holding Power

In a typical shaft and collar assembly, Fig. 1, force F developed by the set-screw point on the shaft due to tightening produces an equal reaction force, F_1. This clamping action results in two frictional forces: One between the shaft and collar, F_2, and another between the shaft and point. These forces provide most of the resistance to relative axial or rotational movement of the parts. Some additional resistance is contributed by point penetration. Total static holding power, then, is a function of all three of these factors, and can be expressed as a single effective force acting at surface of shaft.

This single force equals the axial holding power, or the resistance of the assembly to relative movement along the longitudinal axis of the shaft. Torsional holding power is determined by multiplying the axial (tangential) holding power by the shaft radius. Either or both of these quantities represent the design holding power of an assembly and are used as the basis for selecting the set-screw diameter and specifying the seating torque.

Size Selection

Typical data used as a basis for selecting set-screw diameter and seating torque for a given shaft diameter are presented in Table 1. These data were determined experimentally. Alloy-steel, cup-point socket set screws of various sizes were seated

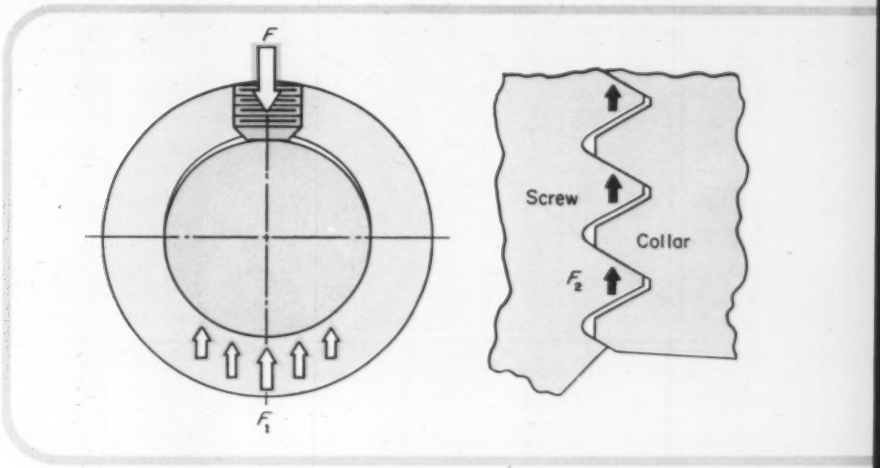


Fig. 1—Shaft and collar assembly shows forces developed in typical set screw installation.

at recommended installation torques on different diameter shafts with surface hardness of Rockwell C 15. Screw threads were Class 3A, tapped holes were Class 2B. For this tabulation, holding power was defined as the minimum load necessary to produce 0.01 in. of relative movement between the shaft and the collar. However, any movement in a set-screw assembly is deemed failure.

Tabulated axial and torsional holding powers are ultimate strengths and should be coupled with specific safety factors appropriate to the given application and load conditions. Good results have been obtained with a safety factor of 1.5 to 2.0 under static load conditions and 4.0 to 8.0 under various dynamic situations. The values shown in bold type in Table 1 indicate holding powers of set-screw sizes selected by the conventional rule-of-thumb method: Screw diameter should be roughly equal to one-half shaft diameter.

Although Table 1 was developed for a specific set-screw form, and point style, these values can be modified by percentage factors to yield suitable design data for almost any other set-screw form and point style. An analysis of the considerations involved is presented here to aid in selecting the optimum set-screw size for any requirement.

Seating Torque: Extensive tests have shown that torsional holding power is almost directly proportional to the seating torque of socket set screws. A typical plot of this characteristic is shown in Fig. 2. Hence, within the strength limits of the assembly, an increase of 50 per cent in the seating torque will increase the holding power by 50 per cent. Likewise, a decrease in the seating torque will decrease the holding power. For example, the torsional holding power of a ½-in. diameter set-screw seated at 310 lb-in. on a 1-in. shaft, Table 1, would be 750 lb-in., or one-half of the tabulated value.

Point Style: The set-screw point, by its penetration, can contribute as much as 15 per cent to the total holding power. The cone point, which penetrates the deepest for a given installation torque, gives the greatest increase, while the oval point, which has the least contact area, gives the smallest increase. If the index for the cup point is taken as 1, the holding power values from Table 1 should be multiplied by 1.07 for cone points, 0.92 for flat or dog points, and 0.90 for oval points. These values assume that the point of the screw is not specially recessed into the shaft and that the penetration is the sole result of tightening. A dog point, for example, seated in a hole drilled in shaft, is actually acting as a pin, and the holding power must be determined by the shear strength of the screw material.

The selection of the type of driver, and, thus, the set-screw form, will normally be determined by factors other than tightening. Despite higher tightenability, the square head has a major disadvantage: It protrudes. Factors of compactness, weight-saving, safety, and appearance may dictate the use of the flush-seating socket or slotted-headless forms.

Thread Type: Tabulated values apply to either thread type, since experimental work indicates that a negligible difference exists in the performance of coarse and fine threads of the same class of fit.

Relative Hardness: Hardness seems to become a significant factor in set-screw selection when there is less than 10 Rockwell C-scale points difference between set-screw point and shafting. As indicated in the typical plot, Fig. 3, there is a slight, gradual decrease in holding power (about six per cent) with increasing shaft hardness up to 10 Rockwell points below the hardness of the screw (Rockwell C 50). Then a loss of about 15 per cent of holding power is experienced. This 15 per cent loss represents primarily the amount of holding power contributed by penetration of the point. Hence, since the hardness affects the ability of the set screw to penetrate, this loss of holding power is actually a function

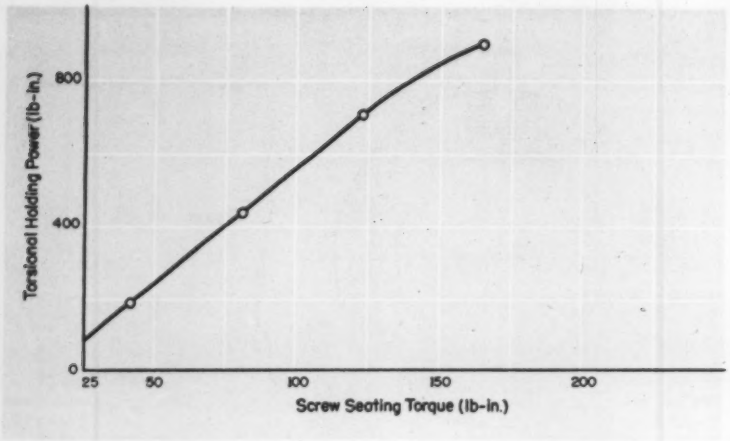


Fig. 2—Torsional holding-power is almost directly proportioned to seating torque. Set screw used to obtain plot was 5/16-in. knurled cup-point type seated on 1-in. diameter shaft with hardness Rockwell C 15.

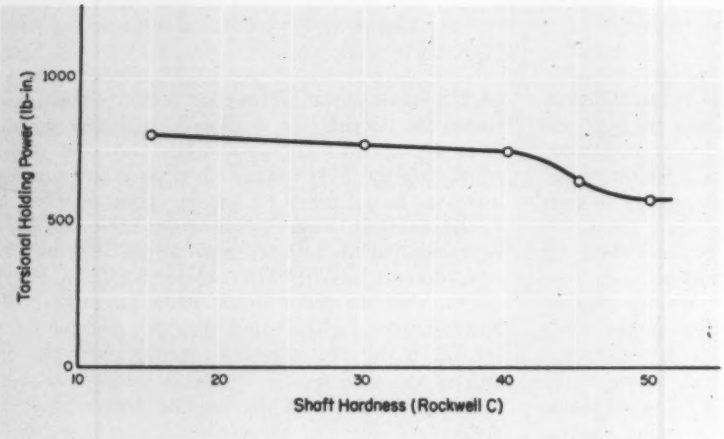


Fig. 3—Considerable loss in holding power is experienced when the difference in hardness between shaft and screw is less than 10 Rockwell C points. Set screw used to obtain plot was 5/16-in. knurled cup-point type seated with 165 lb-in. against 1-in. diameter shaft with hardness Rockwell C 50.

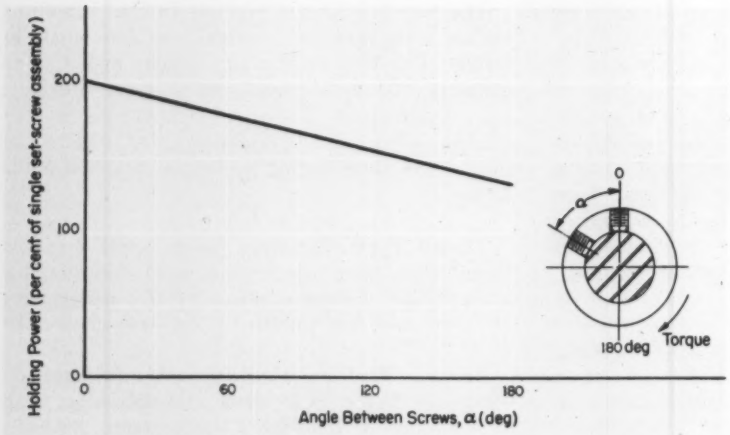


Fig. 4—Angle between two set screws has a straight line effect on torsional holding-power.

of the lack of point penetration.

The plot, Fig. 3, is based on a relatively hard, Rockwell C 50, screw point but the 10-Rockwell point differential can be applied generally. Thus for a screw hardness of Rockwell C 45, a 15 to 20 per cent loss in holding power should be expected if the shaft hardness is Rockwell C 35 or greater.

Flatted Shafting: Only about six per cent more torsional holding power can be expected when screw seats on flat surface. Flatting does little to prevent the 0.01-in. relative movement established here as criterion of failure. Axial holding power is same.

Length of Thread Engagement: The length of

thread engagement has no noticeable effect on axial and torsional holding power, provided there is sufficient engagement to prevent thread stripping in tightening. The length of engagement depends upon such factors as the amount of applied load, type of material, type of thread, and screw diameter. In general, the minimum length of engagement recommended is the diameter of the set-screw. This usually permits the development of the recommended seating torque without danger of thread stripping. The tabulated values for seating torque were developed with the assumption that the engagement length was long enough to prevent stripping.

Type of Driver: The values tabulated in Table 1 are for socket type set screws. However, they apply equally well to slotted and square-head set screws provided the indicated seating torque is developed. The shape of the driver itself has no direct bearing on the holding power. However, the shape of the driver does have an effect on the seating torque.

For the slotted set screw, the maximum seating torque is that which can be developed by a screw driver. This value is usually less than the torque required to strip the screw threads. Hence, the torque which can be developed is a function of the driver.

For socket or fluted set-screws, the maximum torque which can be developed is a function of the strength of the driver or key, and not that of the screw threads. For the square-head set screw, the maximum possible seating torque is a function of the screw thread strength, since a torque greater than the stripping strength usually can be developed with a wrench. Hence, for the socket, fluted, and slotted-type set screws, the seating torque is a function of the type of driver, but for the square-head set screw it is a function of the thread strength. Tabulated for convenience and comparison are typical recommended installation torques for square-head set screws, Table 2.

For example a 5/16-in. socket set screw used in these tests, and seated to its recommended torque of 165 lb-in. developed torsional holding power of 562 lb-in. on a ¾-in. diameter shaft. However, only approximately 45 per cent of the holding power could be realized with the same size slotted set screw if tightened to its normal seating torque of 75 lb-in. This is the average torque developed manually with a screw driver.

Number of Set Screws: Two set screws give more holding power than one, but not necessarily twice as much. The tabulated torsional and/or axial holding powers, Table 1, can be multiplied by from 1.30 to 2.00, depending on the angle between the two screws. The holding power is approximately doubled when the second screw is installed in an axial line with the first, but is only about 30 per cent greater when the screws are diametrically opposed. The plot, Fig. 4, shows how much to compensate for any angle in between. Where design dictates that the two screws both be installed on the same circumferential line, an optimum displacement of 60 deg is recommended as the best compromise between maximum holding power and minimum metal between tapped holes. This displacement gives 1.75 times the holding power than one screw alone will give.

Table 2—Recommended Seating Torques for Alloy-Steel Square-Head Set Screws

Nominal Size (in.)	Seating Torque (lb-in.)	Nominal Size (in.)	Seating Torque (lb-in.)
1/4	145	5/8	2,550
5/16	300	3/4	4,500
3/8	500	7/8	7,250
7/16	850	1	10,550
1/2	1,275		

Plating: An increase of 5 to 10 per cent in the holding power for the same tightening torque can be anticipated when the screw is plated with a soft plating such as cadmium or zinc. The plating acts as a lubricant and less of the applied tightening energy is dissipated in friction at the mating threads. A comparable increase can be achieved by plating the female tapped member, or by using a suitable lubricant.

Screw Retention

Keeping a set screw tightly seated is not so much a factor in developing axial and torsional holding power as it is in maintaining it. A nut and bolt assembly can be fairly loose and still hold parts together for a considerable time. But as soon as a set screw loosens, the fastened parts normally will separate. An exception is the case of the dog point seated in a drilled hole. Even here, failure would follow rapidly after initial loosening.

As for axial and torsional holding power, seating torque is essential to secure retention of the screw. As the screw, Fig. 1, is tightened, the resultant pressure on the point forces the screw back against the flanks of the threads in the tapped hole where friction is developed. This friction at the thread flanks plus that at the point of contact of screw and shaft hold the screw in place.

The point of the screw then plays an important role in keeping the screw tight under dynamic loads, much more so than it does in developing torsional or axial holding power. The cup point is much better than the other points in this respect. In addition to the standard screw points, several screw designs which have special self-locking features have been developed.

The set-screw diameter is also a factor in developing vibrational holding power. It does not, however, lend itself to a neat quantitative analysis. In general, a size or two larger set screw may often be the solution in applications where other means have failed to develop satisfactory vibrational holding power. The larger screw permits higher seating torque and thus develops a clamping force which is greater.

Determining Line Size

PERFORMANCE of hydraulic systems for power or control is measured by the efficiency with which usable pressure and flow are delivered to the output. Therefore, the line must be of the right size to convey pressure and flow with maximum efficiency.

In this second article of a planned program, selection of the proper hydraulic line size is discussed in terms of two required line properties:

1. Wall thickness of hydraulic lines must be large enough to withstand operational pressure and surge-pressure peaks, and must include predetermined safety factors.
2. Cross-sectional flow area of hydraulic lines must be large enough to prevent large pressure drops, which consume transmitted energy and convert the energy to heat.

Wall Thickness

While different practices for determining wall thicknesses are used, depending on the type of line in question, the basic considerations are: 1. Pressure transmitted by the line. 2. Material of line. 3. Type of service application. The last of these considerations includes magnitude and frequency of pressure surges, amount of mechanical abuse, vibration effects, and corrosion. All of these service conditions are usually expressed in terms of a safety factor.

As an indication of the importance of these three factors, the JIC Hydraulic Standards contain the following general definitions and recommendations:

1. Definition of pressures:
   - 0- 200 : Low
   - 200- 500 : Medium
   - 500-1200 : Medium High
   - 1200-3000 : High
   - 3000 up : Extra High
2. Piping shall have adequate strength to withstand additional pressure, including surge pressure, within the safety limits of the entire circuit. A factor of safety of at least eight over normal working pressure is suggested.
3. The strength of the piping shall be adequate to withstand the maximum rate of surge pressure rise and the maximum surge peak-pressure at the frequency developed by the cycling of the equipment operation.

Once the system requirements for the lines have been determined, the wall thickness required to handle the flow and pressure must be determined.

Thin-Walled Lines: If the stress distribution across the width of the line wall is assumed uniform, a simplified and elementary method of wall thickness calculation can be used. The assumption of uniform stress distribution is justified if the ratio of wall thickness to pipe diameter is small, 0.07 or less. Lines with these characteristics are referred to as thin walled.

If a thin-walled line is subjected to internal pressure, the stress in the walls occurs in two prin-

Nomenclature

D = Diameter, ft	M = Safety factor	v = Velocity, fps
d_{eq} = Equivalent diameter, in.	P = Pressure, psf	$\gamma = \rho g$ = Specific weight, lb/ft^3
d_i = Inside diameter, in.	ΔP = Pressure drop, psf	ζ = Proportionally coefficient
d_o = Outside diameter, in.	p = Pressure, psi	θ = Radial angle, deg
F = Force, lb	p_w = Working pressure, psi	μ = Dynamic viscosity, lb-sec/ft^2
F_r = Radial force, lb	Δp = Pressure differential, psi	ν = Kinematic viscosity, cS
f_f = Friction factor	Q = Flow rate, gpm	$\rho = \gamma/g$ = Density, lb-sec^2/ft^4
G = Specific gravity	R = Reynolds number	σ = Stress, psi
g = Gravitational constant, ft/sec^2	r = Radius, in.	σ_a = Allowable stress, psi
L = Length, ft	s = Thickness, in.	τ = Frictional resistance, psi
l = Length, in.		

JAROSLAV J. TABOREK
Research and Development Engineer
Phillips Petroleum Co.
Bartlesville, Okla.

cipal planes: Longitudinal or axial, and radial, Fig. 1. The total radial separating force acting on the longitudinal parting plane, Fig. 1*a*, is (see Nomenclature)

$$F = \int p l ds \cos \theta \tag{1}$$

Since $ds = r\, d\theta$, Equation 1 becomes

$$F = plr \int_{-\pi/2}^{+\pi/2} \cos \theta\, d\theta = 2plr = pld_i \tag{2}$$

Also, the resisting force set up in the longitudinal section by the material is

$$F_r = 2sl\sigma \tag{3}$$

Since the force set up in the section by the internal pressure is resisted by the strength of the material only, Equations 2 and 3 are combined to obtain the average tangential stress in the wall:

$$\sigma = p \frac{d_i}{2s} \tag{4}$$

By a similar analysis, the longitudinal stress acting on the radial plane, Fig. 1*b*, is

$$\sigma = p \frac{d_i}{4s} \tag{5}$$

A comparison of Equations 4 and 5 shows that the longitudinal stress is one-half of the tangential stress. Hence, the tangential stress is the limiting stress in thin-walled line selection. Use of the tangential stress as a limit has been substantiated by experiments which prove that pipes burst in the longitudinal direction.

With a safety factor, the allowable working pressure of a thin-walled line is:

$$p_w = 2 \frac{s\sigma_a}{d_i M} \tag{6}$$

By rearranging terms in Equation 6, the required wall thickness is obtained:

$$s = \frac{p_w d_i M}{2\sigma_a} \tag{7}$$

Thick-Walled Lines: In practice, a large portion of lines used do not comply with the $s/d_i < 0.07$

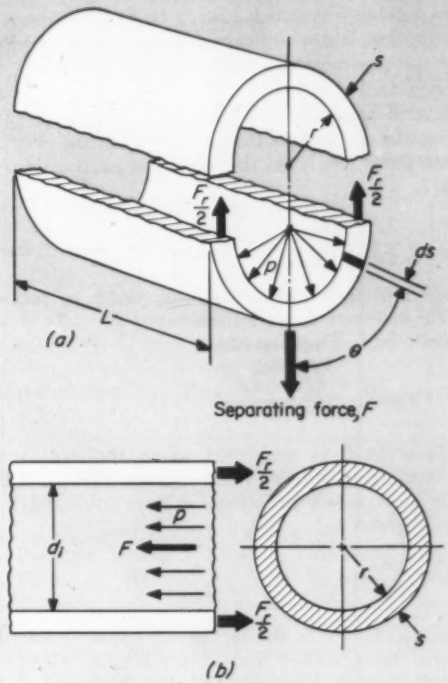


Fig. 1—Stresses developed in hydraulic lines; *a*, tangential, and *b*, longitudinal

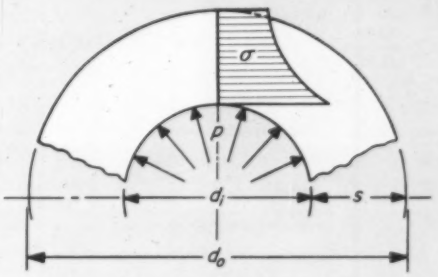


Fig. 2—Stress distribution in thick-walled lines

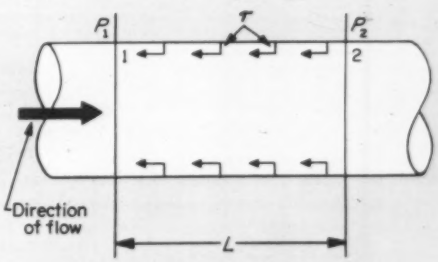


Fig. 3—Frictional resistance in hydraulic lines

requirement. Working pressure and required thickness equations derived for thin-walled lines are invalid for lines in which $s/d_i > 0.07$, since the stress distribution is not uniform across the wall thickness and the stress reaches a maximum of the inside wall of the line, Fig. 2.

Several equations have been developed for calculating the maximum or inside wall stress. For rigorous stress analysis, the equation most commonly used is

$$\sigma = p \frac{d_o^2 + d_i^2}{d_o^2 - d_i^2} \tag{8}$$

Since line sizes are usually expressed in terms of inside diameter and wall thickness, $d_i + 2s = d_o$ is substituted in Equation 8:

$$\sigma = p \frac{2d_i^2 + 4d_i s + 4s^2}{4(d_i s + s^2)} \tag{9}$$

Equation 9 is simplified when the $s/d_i \approx 0.10$ by neglecting the s^2 term. This simplification results in Barlow's equation for lines subjected to internal pressures:

$$\sigma = p \frac{d_o}{2s} \tag{10}$$

Equation 10 is similar to Equation 4 for thin-walled lines, except that d_o replaces d_i. Hence, the permissible working pressure for thick-walled lines is smaller than calculated by Equation 4. When a safety factor is introduced, the equation for permissible working-pressures in thick-walled lines is obtained from the equation

$$p_w = \frac{2s\sigma_a}{d_o M} \tag{11}$$

Hence, for thick-walled lines, the required wall thickness is

$$s = \frac{p_w d_o M}{2\sigma_a} \tag{12}$$

Numerical values of the allowable tensile stress, σ_a, are a function of the operating temperature, and values of the safety factor, M, vary between 4 and 10 depending upon the application.

Line Diameter

All of the various factors affecting hydraulic lines, must be considered as a group for the ultimate selection of a certain line diameter.

In general, small line diameters are preferred for economic reasons. However, definite practical and conventional restrictions are placed on the magnitude of flow, and hence the line diameter. As defined by JIC Standards, the optimum line diameter must give a cross-sectional area of line large enough so that the flow capacity is sufficient on the suction side to prevent cavitation or starvation of the pump; and on the discharge side to prevent undue temperature rise or turbulence. This definition is vague, hence, the factors affecting line size selection will be summarized and treated in greater detail.

Since the type of fluid flow through a line determines to a large extent the effect which various factors have on line selection, information of design value can be obtained through an analysis of flow conditions.

Types of Fluid Flow: If a fluid moves through a pipe at low velocity, the path of fluid particles is

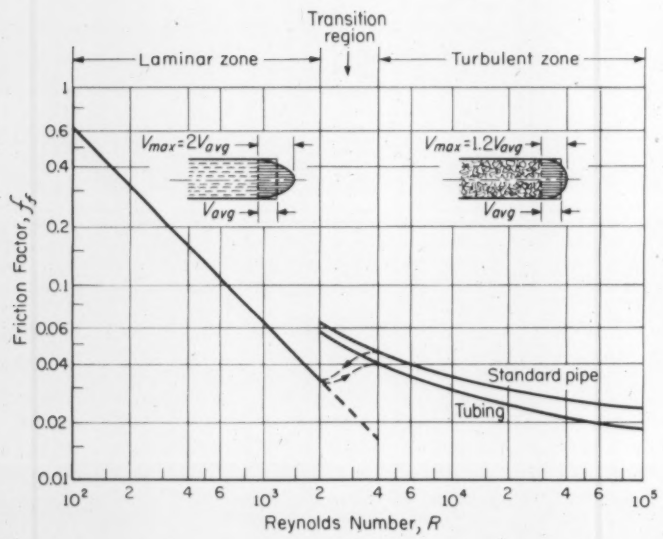


Fig. 4—Friction factor as a function of Reynolds number

parallel to the pipe axis, and the velocity profile is parabolic. This low-velocity flow is called laminar flow.

After the flow velocity has reached certain magnitude, the particles do not follow an orderly path, but are thrown against the walls of the line in a whirling motion. This high velocity flow is called turbulent flow, and the velocity profile for turbulent flow is much steeper than that for laminar flow.

Since each type of flow is determined by a different set of physical laws, the decision on which type of flow exists is of primary importance. From the theory of dimensional analysis and from experimental results, the type of flow is directly related to the magnitude of a dimensionless group of units, the Reynolds number, if expressed in consistent units, is

$$R = \frac{Dv\gamma}{\mu g} = \frac{Dv\rho}{\mu} = \frac{Dv}{\nu} \tag{13}$$

R is directly proportional to pipe diameter and flow velocity and inversely proportional to kinematic viscosity. In general, laminar flow exists for values of $R < 2000$, while turbulent flow is established at values of $R > 4000$. The region between 2000 and 4000 is one of transition, and flow pattern changes unpredictably.

To make Reynolds number a practical tool, Equation 13 is expressed in terms of conventional units. In terms of flow velocity,

$$R = 7742 \frac{v d_i}{\nu} \tag{14}$$

Similarly, in terms of flow rate,

$$R = 3163 \frac{Q}{\nu d_i} \tag{15}$$

When the cross section of the line is not circular in shape, an equivalent diameter, which can be substituted in any Reynolds number equation, is determined:

$$d_{eq} = 4 \frac{\text{flow area}}{\text{wetted frictional perimeter}} \tag{16}$$

Friction in Lines: A fluid, flowing through a conduit of diameter D, Fig. 3, develops a pressure differential, $P_1 - P_2$, through the path length, L. This pressure differential, for isothermal flow of noncompressible fluids, originates only in frictional resistance on the conduit walls. By balancing the forces acting at the wall, the pressure drop which results from the unit frictional resistance, τ, is

$$\Delta P = 4\tau \frac{L}{D} \tag{17}$$

Furthermore, since the unit frictional resistance is proportional to the velocity pressure,

$$\tau = \zeta \frac{v^2\gamma}{2g} \tag{18}$$

Hence, a general expression for the pressure drop is obtained by substituting Equation 18 in Equation 17:

$$\Delta P = 4\zeta \frac{v^2\gamma L}{2g D} \tag{19}$$

where the proportionality coefficient, ζ, is the friction coefficient. If $f_f = 4\zeta$ is substituted in Equation 19, the Darcy equation for pressure drop is obtained:

$$\Delta P = f_f \frac{v^2\gamma L}{2g D} \tag{20}$$

Since the friction factor, f_f, is a function of the flow conditions, the exact effect that the type of flow has on the friction factor must be ascertained before a truly valid equation can be set up for the pressure drop.

LAMINAR FLOW: The friction factor is usually represented solely as function of Reynolds number, Fig. 4, since, for laminar flow, the friction factor is independent of the conduit wall quality.

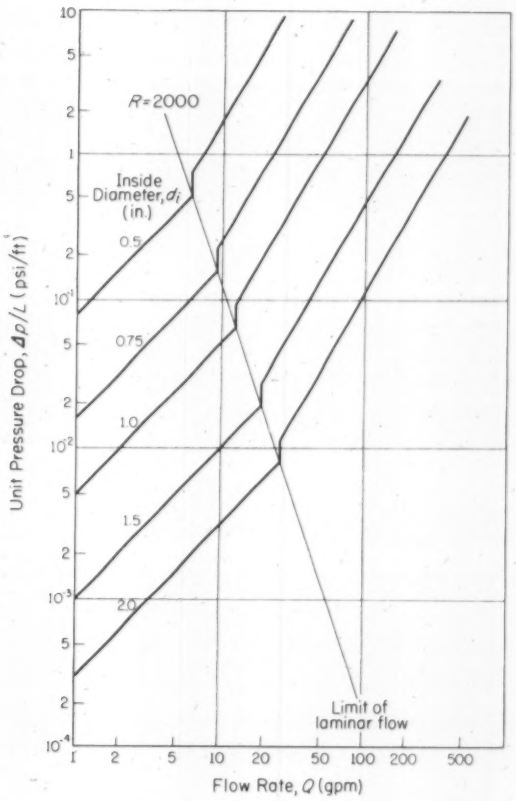


Fig. 5—Unit pressure drop as a function of flow rate. Typical hydraulic fluid, with ν = 20 cS and G = 0.9, is assumed

The dependency of the friction factor on Reynolds number is

$$f_f = \frac{64}{R} \tag{21}$$

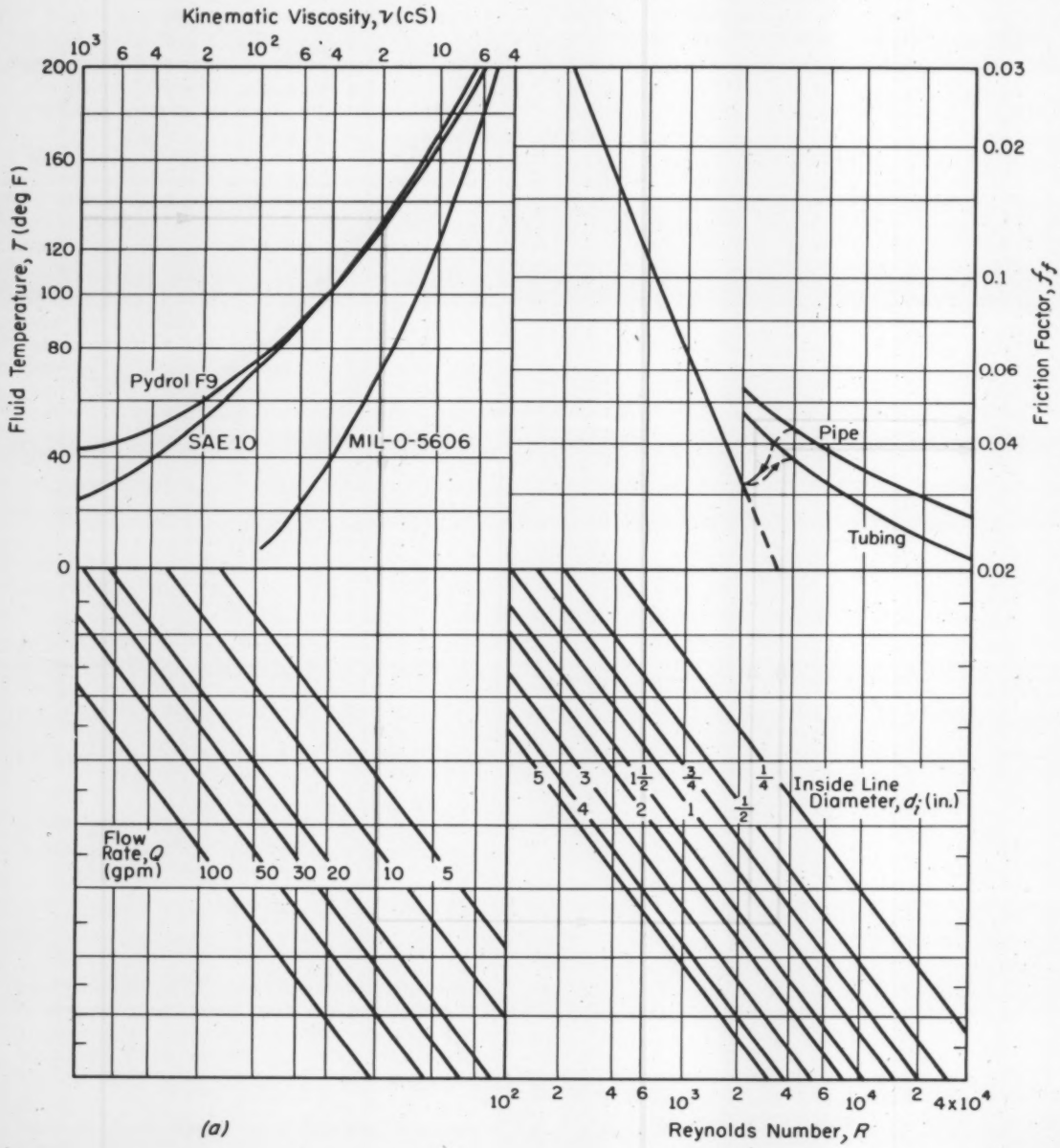
where the representation of this relationship is a straight line up to the turbulence limits, Fig. 4.

Substituting Equation 21 into Equation 20 and simplifying, the valid expression for the pressure drop in the laminar flow region is

$$\Delta p = \frac{vG\nu L}{1497\, d_i^2} = \frac{QG\nu L}{3664\, d_i^4} \tag{22}$$

Hence, the pressure drop is in direct linear proportion to velocity.

TURBULENT FLOW: Since the effects of wall roughness become important under turbulent flow, a general correlation between the friction factor and Reynolds number cannot be found for turbu-



lent flow. All attempts to correlate the friction factor with Reynolds number and wall roughness have relied on experimental data. For hydraulic systems under normal conditions, the equation most commonly used for the friction factor in tubes is

$$f_f = \frac{0.316}{R^{0.25}} \tag{23}$$

Hence, if Equation 23 is substituted into Equation 20, the pressure drop in tubes for turbulent flow is

$$\Delta p = \frac{v^{1.75} G L \nu^{0.25}}{367\, d_i^{1.25}} = \frac{Q^{1.75} G L \nu^{0.25}}{1757\, d_i^{4.75}} \tag{24}$$

For standard pipe, a friction factor ten per cent higher than that used for tubes is recommended.

COMPARISON OF FLOW TYPES: Several important conclusions concerning the effect of flow types on pressure losses caused by friction can be drawn from the preceding discussion:

1. Effect of fluid viscosity on pressure loss is much more pronounced in regions of laminar flow than in regions of turbulent flow.
2. Friction factor values decrease with increases in the Reynolds number regardless of the type of flow in the line. This does not mean that the pressure drop per unit length decreases with higher velocities, since decreases in the friction factor are more than compensated for by the fact that the pressure drop is related to the square of the velocity. Pressure losses per unit length of line for a typical hydraulic circuit are compared for various flow conditions and line sizes in Fig. 5.
3. There is no mathematical expression for the pressure drop in the transient-flow region that exists between laminar and turbulent flows. To include a certain safety factor in design, it is recommended that flow at $R = 2000$ be considered as the point at which the transition from laminar to turbulent flow takes place.

Pressure Drop: The pressure drop, as it affects

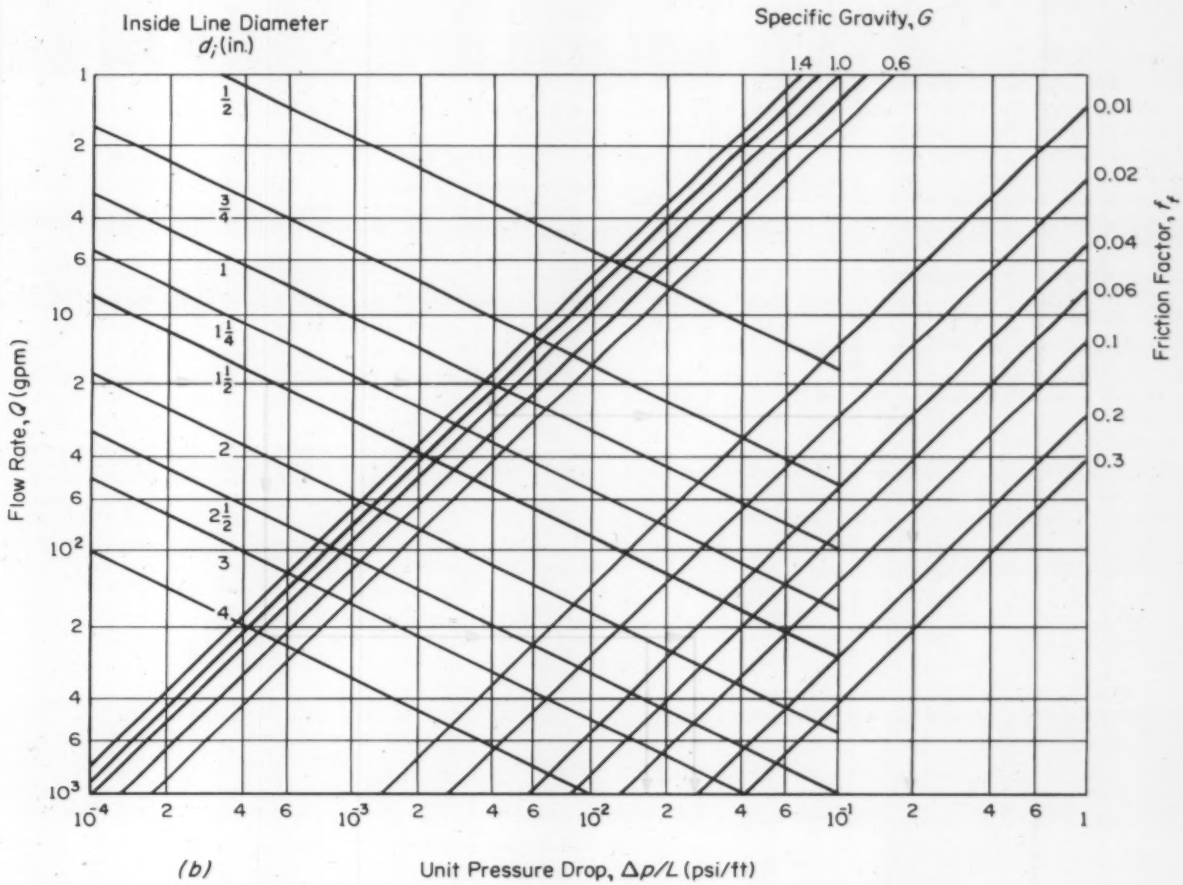


Fig. 6—Diagrams for determination of pressure drop. Charts give, *a*, friction factor as a function of fluid type, fluid temperature, flow rate, and line diameter; *b*, unit pressure drop as a function of flow rate, line diameter, specific gravity, and friction factor

the selection of line size, depends upon the working temperature, fluid viscosity, flow velocity, and line application. Hence, the pressure drop cannot be analyzed by itself.

WORKING TEMPERATURE: Two fundamental considerations determine the optimum working temperature of the circuit: 1. Chemical stability of the fluid. For petroleum based oils, 150 F is a recommended maximum, but the normal working temperature should be somewhat lower. 2. Running clearances of the circuit. Components should be designed to reach their optimum clearance at the fluid temperature.

Thermal equilibrium between the heat generated and the heat dissipated from the system must be reached within the limits of the maximum permissible temperature. System lines must adhere to this operating condition, even if additional components have to be incorported to complement the natural heat transmission from the system. If a line selected is too small, a heat exchanger would have to be included in the system to restore the heat balance. Hence, the advantages of the small line would be lost.

FLUID VISCOSITY: Pressure drop is directly proportional to the fluid viscosity. Hence, it is desirable to use a fluid with the lowest viscosity possible. However, the low limits are governed by the amount of internal leakage permitted, since leakage increases with a decrease in viscosity. Hence, the optimum low viscosity must compromise between these contradictory demands. The minimum viscosity usually recommended is 7 cS or 45 SSU.

The high viscosity limit is determined by the ability of the fluid to form a lubricating film. The high limit usually recommended is 900 cS or 4000 SSU. Also, fluid viscosity reaches its maximum under low-temperature starting conditions. Hence, fluids should be selected that will operate within the viscosity range.

Because of this wide range in fluid viscosities for optimum performance, considerable pressure drops are introduced. Under laminar flow, the pressure drop which occurs when the fluid changes from one viscosity to another is obtained from

$$\frac{\Delta p_1}{\Delta p_2} = \frac{\nu_1}{\nu_2} \qquad (25)$$

where subscript 1 represents starting conditions and subscript 2 represents normal operating condition. For turbulent flow, the pressure drop ratio is

$$\frac{\Delta p_1}{\Delta p_2} = \left(\frac{\nu_1}{\nu_2}\right)^{0.25} \qquad (26)$$

Hence, the pressure drop is much more sensitive to variations in viscosity in the laminar flow region than in the turbulent flow region.

FLOW VELOCITY: While the preceding operating conditions are unalterable, the proper selection of line size can control the flow velocity, which affects each of the other factors.

Over-all selection of size depends upon, first, the choice between laminar and turbulent flow, and second, pressure surges.

In general, pump suction lines should operate in the laminar region, while lines on the pressure side of the pump can operate satisfactorily with a certain degree of turbulence. Laminar flow is achieved without undue difficulty in short and straight suction lines. To assure laminarity of the suction flow, the viscosity at the highest operating temperature must be considered. However, laminarity of the suction flow is an over-all condition, while the permissible pump vacuum determines the actual pressure drop which can be tolerated without cavitation.

Also, the pressure drop in the suction line at low temperatures and high viscosities must be investigated.

In lines on the pressure side of the pump, a certain degree of induced turbulence will be introduced by fittings and line restrictions and will exist down to Reynolds numbers of approximately 1000.

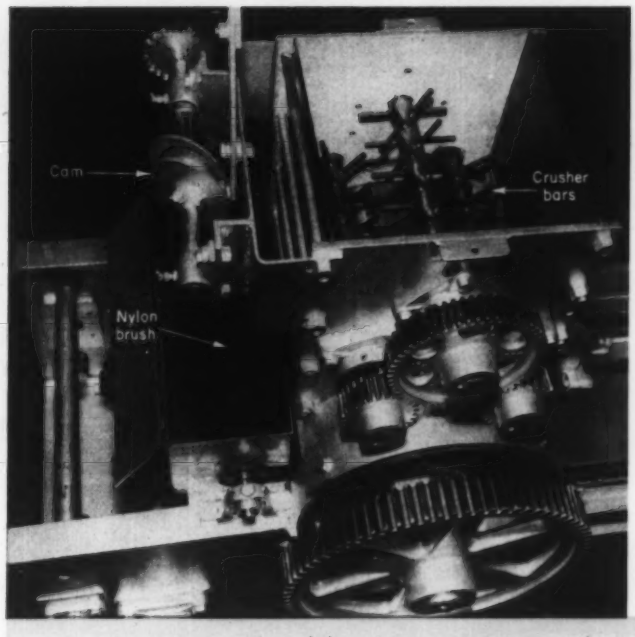
For selection of lines to accommodate pressure surges, flow velocities should be kept between 10 and 20 fps which will give surge pressures of 600 to 1200 psi. However, the thermal performance with respect to pressure drop again becomes the primary consideration. However, one exception to these optimum flow velocity values exists when discharge lines carry the normal pump flow plus the return flow from single-acting cylinders. For such temporary peaks, the velocity limits may be interpreted somewhat liberally.

GRAPHICAL CALCULATIONS: All the factors which influence pressure drop calculations are combined into a two-part diagram, Fig. 6. Pressure drop under minimum and maximum operating temperatures and for various line sizes can be ascertained with sufficient accuracy for most engineering calculations. If a different fluid is used, its characteristics are added to the proper part of the diagram without affecting the remaining portion of the diagram.

For example, assume a system operated with SAE 10 oil at 132 F in tubing. The flow rate of 20 gpm goes through a 1½-in. suction line and a 1-in. pressure line. From chart *a*, Fig. 6, f_f = 0.039 for 1-in. line, assuming turbulent flow. For the 1½-in. suction line, the flow is just out of the laminar region. This is assumed acceptable. From chart *b*, the pressure drop for the pressure line is 0.2. For the suction line, with laminar flow and f_f = 0.028, the pressure drop is 0.018, while for the suction line with turbulent flow, f = 0.045, the pressure drop is 0.027.

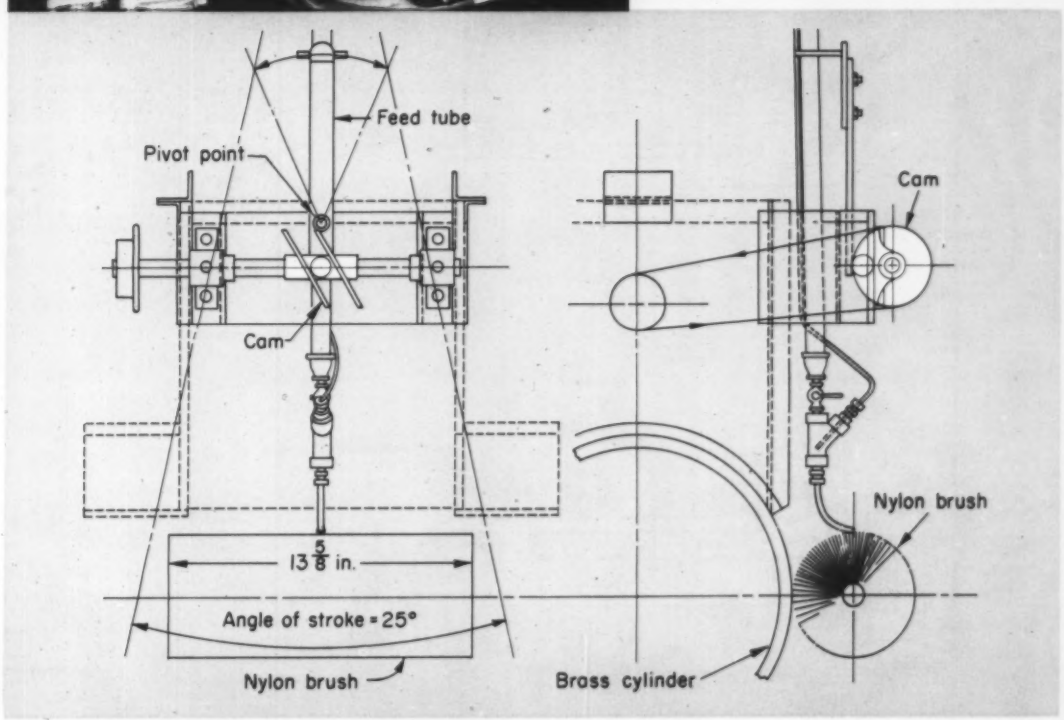
The third article in this planned program will be titled "Selection of Hydraulic Tubing," and will discuss the general types of commercial tubing available, their sizes, and application in hydraulic systems. As part of this program, a previous article, "Fundamentals of Line Flow," was published in MACHINE DESIGN, April 16, 1959.

Discs Welded to a Pipe Make Low-Cost Cam



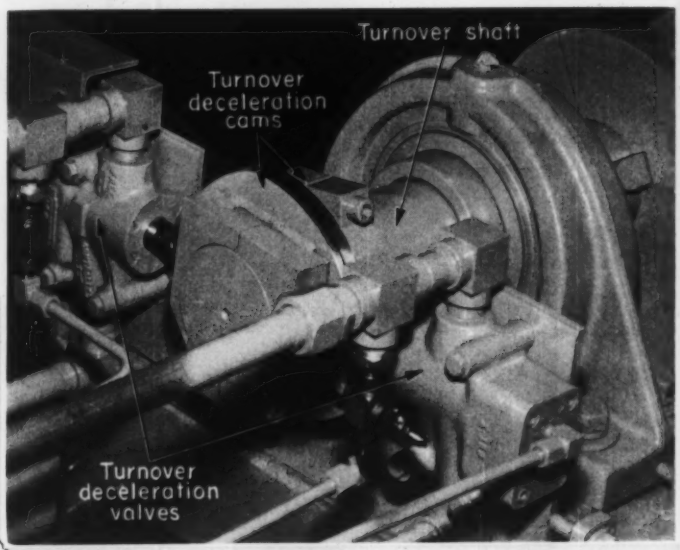
SLOW-SPEED OSCILLATING MOTION is produced by a cylindrical cam of simple design. The cam is fabricated from two oval-shaped discs welded to a short length of pipe at an angle of 30 degrees to the centerline.

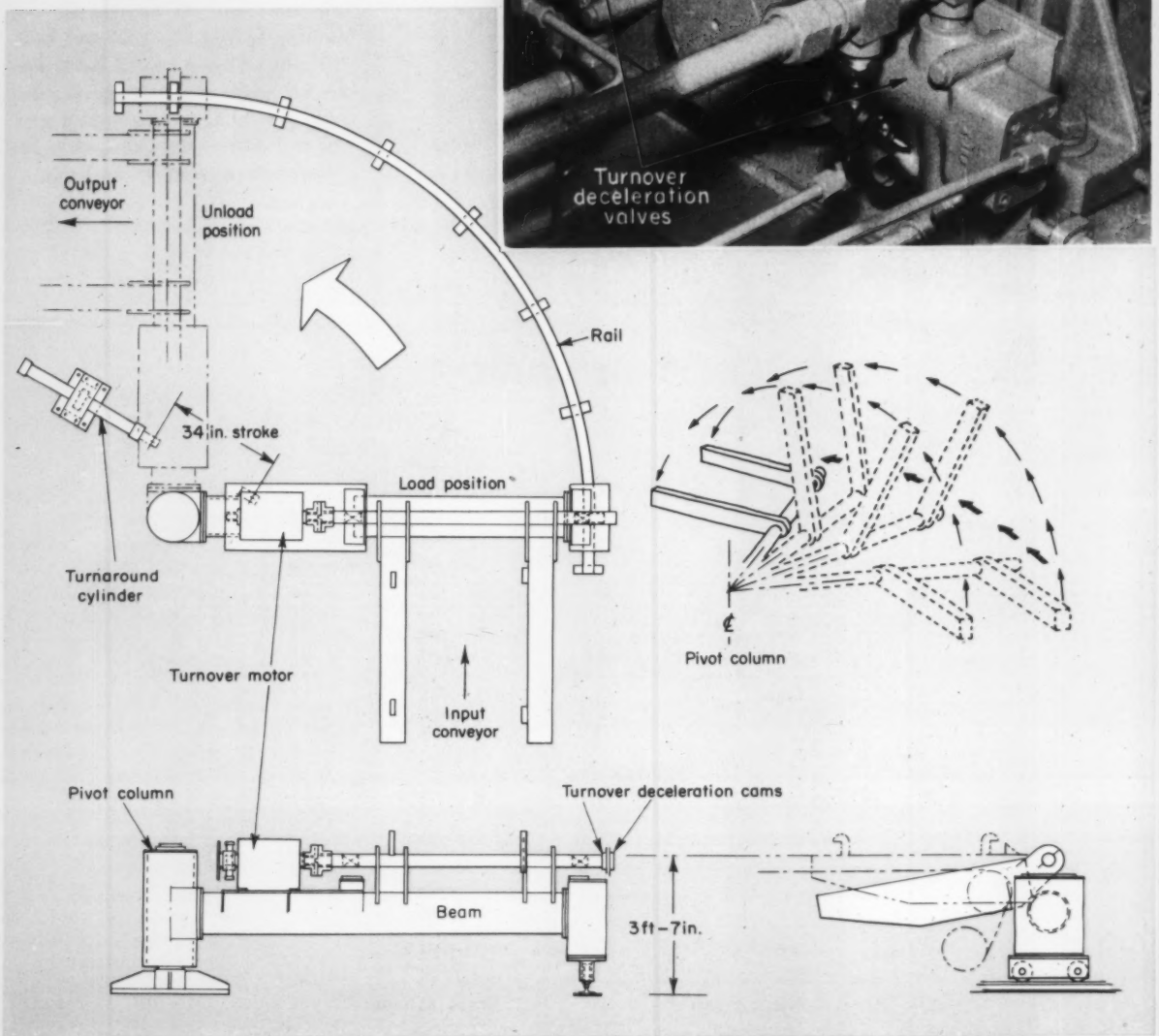
Applied in the design of Hersey Sugar Cuber machine built by Standard Steel Corp., Los Angeles, the cam oscillates a feed tube back and forth. The tube sprays a special liquid over the full width of a nylon brush. The surface of the sugar-cube-making cylinder and cube-ejection plungers in the cylinder are cleaned by the brush.



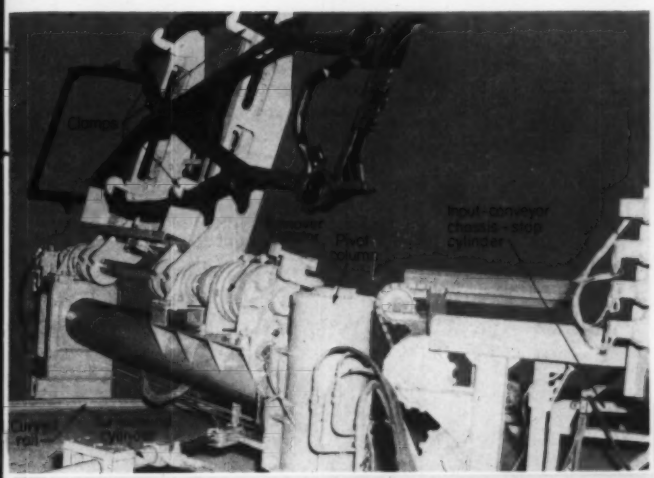
Cam-Operated Deceleration Valves

HIGH-SPEED AUTOMATIC TURNOVER of heavy members is accomplished in a special machine designed with a novel mechanical-electrical-hydraulic control system. The equipment simultaneously turns over automobile chassis, one at a time, and rotates them through a 90-degree angle at the rate of three per minute. The complete machine was built by International Conveyor & Washer Corp., Detroit.



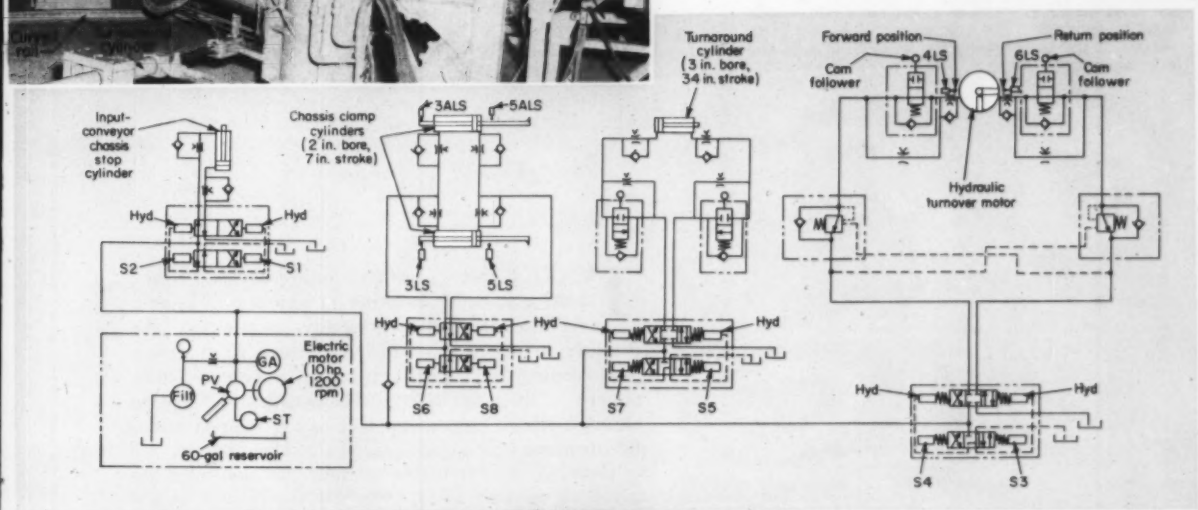


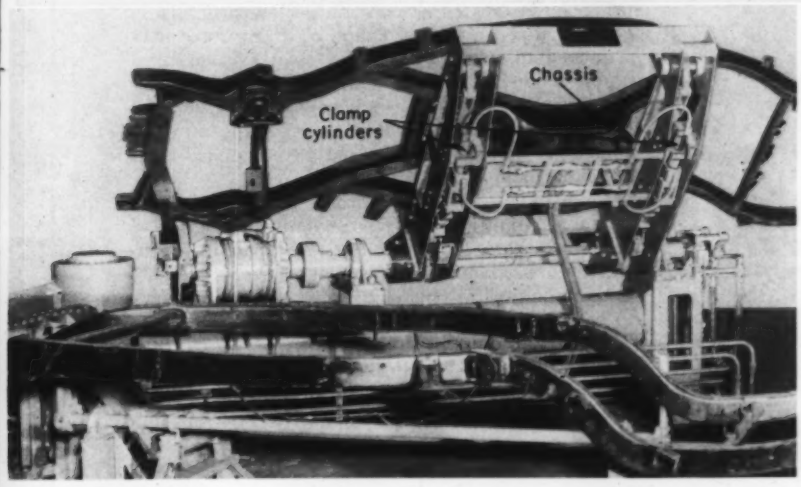
Control Braking of Heavy Members



SMOOTH, RAPID STOPPING of the turnover and turnaround members at the load and unload positions is achieved by a carefully designed combination of relief, by-pass, and deceleration valves. Two split cams for controlling the turnover deceleration valves are mounted at the end of the beam base. Cams for the turnaround deceleration valves are at the column base.

The rotary actuator motor in the turnover develops 44,000 lb-in. of torque at 500 psi. A 3-in. bore cylinder pulls the turnaround unit through 90 degrees and pushes it back again during each cycle.

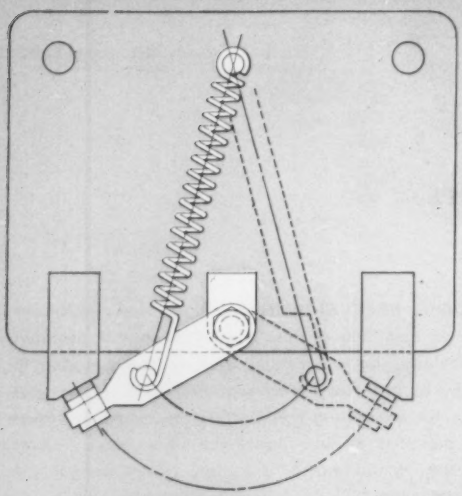




SEQUENCE OF OPERATIONS for a cycle begins at the load position with the turnover arms located under an automobile chassis on the input conveyor. The turnover arms rotate up. When they reach the horizontal position, they actuate clamp-relay limit switches and turnaround-relay limit switches. At the unload position, the reverse occurs, the chassis is unclamped, and the turnover-turnaround unit comes back to the load position.

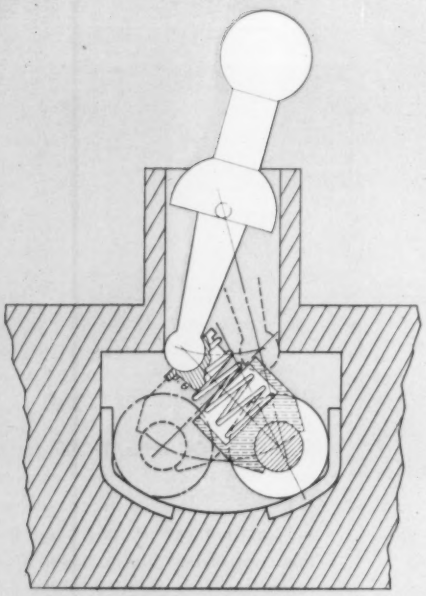
For safety, the cycle automatically stops if the clamps are not in position by the time the arms rotate 45 degrees.

FRANK A. VOTTA JR.
Chief Engineer
Hunter Spring Co.
Lansdale, Pa.



Over-Center Extension-Spring

Mounted between a fixed point and a movable lever, the extension spring in this simplified toggle device holds the lever against a stop. Upon release of any external force which may have moved it, the lever returns to one of two definite positions, depending upon location of the spring with respect to the fixed center of rotation at the time the outside force is removed. The component of spring force normal to the lever creates the moment to hold the lever against the stop.



Compression-Spring Toggle

The tendency to buckle makes the compression spring difficult to use as the linkage between toggling and toggled members. Because of lateral force imposed on the spring, a mounting similar to that shown must be used. The spring is seated in a cup which pivots on the hub of the rolling movable contact. The activating lever contacts the spring through an internal collar. Both serve to prevent buckling as the spring actuates the contact.

TOGGLE springs are positioning devices. They hold a movable member in any one of several definite locations, normally positioning the member to one side or the other of a fixed center and keeping it in firm contact with another component. Often the spring also provides the linkage through which force is applied to the toggled member to move it from one position to the other.

Usually, the movable member is mounted to pivot on an axis about which a component of the spring force creates a moment. The spring is so mounted that the line of action of spring force may be moved to either side of the pivot axis, or fixed center. When the line of action passes over this axis, the sense of the moment is reversed and the member pivots. Final position of the movable member is normally determined by stationary stops or contact points.

Typical Applications: Representative toggle-spring mechanisms are shown in the accompanying illustrations. Mechanisms of this type are commonly used in electrical switches and circuit breakers. Springs cause the movable electrical contacts to come to rest only in definite open or closed positions and maintain a definite contact pressure. Toggle springs are also used to flip dogs in latches and locks and to position pawls in ratchet mechanisms.

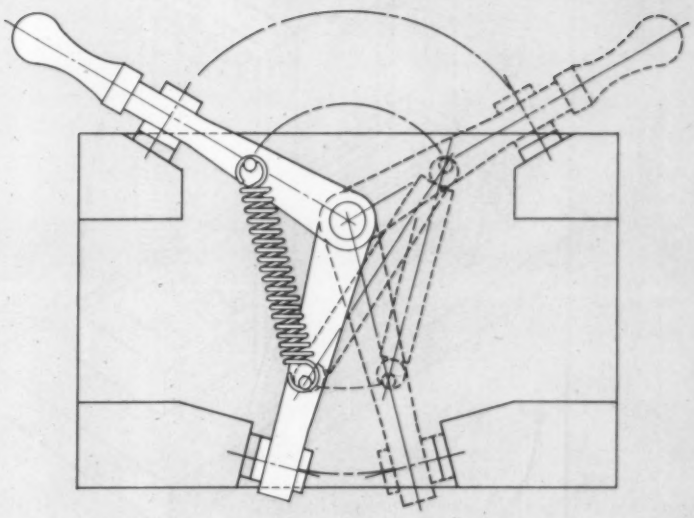
Spring Force: Toggle-spring design is normally

TOGGLE-SPRING MECHANISMS

Five ways to design for snap action with conventional springs

Extension-Spring Toggle

Movement of the actuating lever in this mechanism will not cause the other lever to break contact until the line of action of the spring passes over center. At that time the lower lever will move directly to the second predetermined position. This type of toggle stores enough energy through a long stroke to give a definite "snap action." Here, only the top lever can actuate the mechanism. No movement of the longer, lower lever is sufficient to reverse the sense of the moment imposed by the spring on the upper lever.



influenced by forces at two different deflections. Most important is the force exerted by the spring at the rest position. Its magnitude will depend upon the contact pressure desired and whether secure holding or mere positioning of the movable components is the purpose of the toggle spring.

Contact or holding force is almost always a vector component of the total force exerted by the spring. Relative magnitudes of the force components on either side of fixed center will depend upon spring gradient and position of spring and contact points.

Force of the spring when its line of action is directly over center may also be significant. This force will always be greater than that at the rest position when conventional positive-gradient springs are used. Action of the unrestrained spring in seeking its condition of least stress and load causes the toggle to operate. If the over-center force is too great, the mechanism may be difficult to operate. If there is too little difference between maximum load over center and minimum load at rest, the toggle may hesitate or operate sloppily.

Spring Gradient: Relatively low-gradient springs are usually employed for toggle applications, especially where correct contact pressure must be maintained within close limits. These springs maintain nearly uniform contact pressure despite changes in spring deflection that result from wear of associated components. Differential load should always be enough to develop positive action without making operation difficult. Where wear is an extreme problem, spring gradient can be modified to help compensate for dimensional changes.

High spring-gradient may cause difficulties other than those associated with wear and difficult operation. If minute variations in spring deflection cause excessive changes in load, the spring may lose its ability to hold components in correct position.

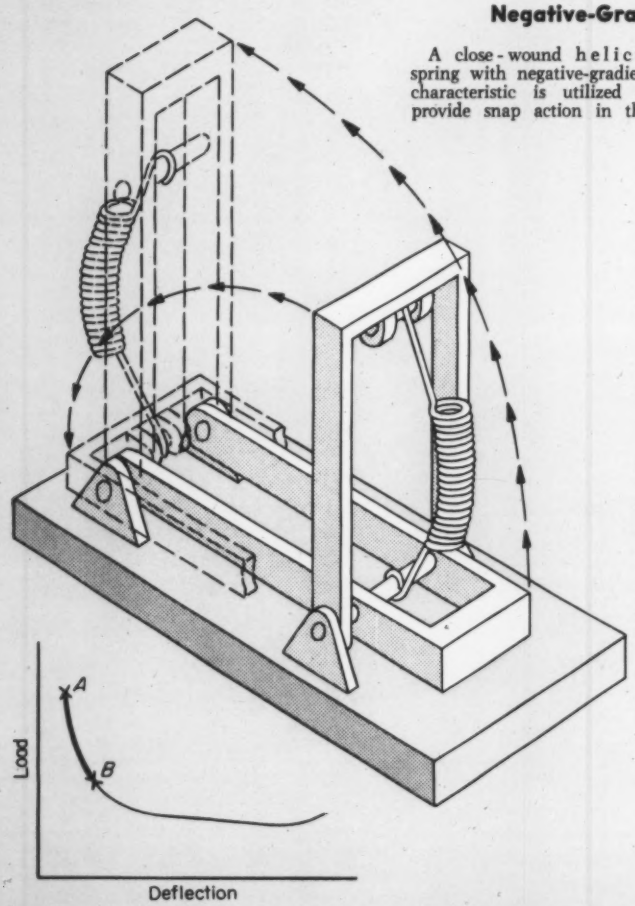
Point of Instability: When the line of action of

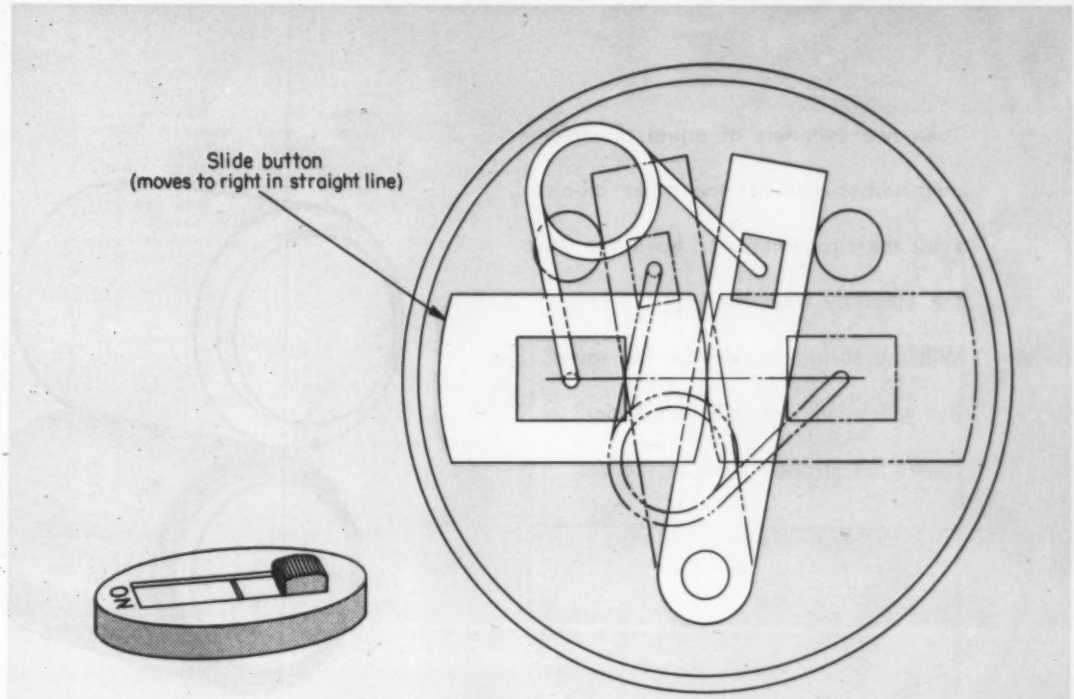
Negative-Gradient Spring Toggle

A close-wound helical spring with negative-gradient characteristic is utilized to provide snap action in this clamping device. Load-deflection characteristics of this spring are shown in the curve plot. For this application, design is based on the portion of the curve between points *A* and *B*. Only slightly compressed from its free length in the clamping position, the spring provides a strong holding force. However, very little effort is required to reverse the clamps.

When the upright lever is pivoted to the rear, the spring must be compressed only slightly before its line of action is moved past the center of rotation of the horizontal lever. This reverses the sense of the moment, and the toggled lever is snapped upright by the spring as it expands in seeking the condition of least stress. Thus, the position of the two levers is reversed. The action is reversible.

A flat columnar spring behaves in a somewhat similar manner. The force required to deflect it from full extension to the buckling point cannot be exactly determined but is high in magnitude. It decreases sharply until the buckling point is reached. Therefore, if the spring is not deflected to buckling, it can be used in toggle devices as a negative-gradient type spring.





Torsion-Spring Toggle

Torsion springs can be designed to provide very positive snap action. In this two-position device, one arm of a helical torsion-spring is mounted in the actuating lever. The other arm is mounted in the actuated or toggled lever. Each arm is free to rotate. The body of the spring is unsupported and also free to rotate.

The actuating lever for this design is a button arranged to slide linearly in a slot. As the button is moved along the slot, it pulls its spring arm with it, causing the spring, and its line of force, to rotate. Spring force always passes through the contact points of both arms. Thus, when the button-mounted spring arm crosses the centerline of the lever, the line of force does also and the lever pivots swiftly to the second position.

the spring is directly over center, an unstable condition exists. Although the total force exerted by conventional toggle springs is greatest at this point, the vector component causing the spring to toggle decreases as this point is approached and reaches zero when the mechanism is directly over center. At this point, appreciable friction or a broad transition area could cause the mechanism to "hang up."

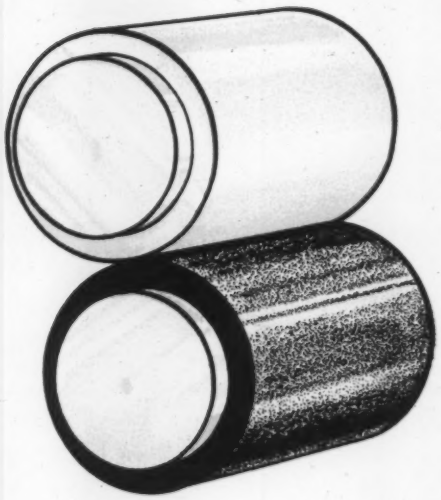
One way to counteract this tendency is to make the fit between springs and levers so loose it will be difficult to maintain position of the line of action of the spring exactly over center. In the torsion-spring toggle-mechanism shown here the hole in the actuated lever is much larger than is required merely to mount the spring arm. This design makes it almost impossible to position the spring so that its line of action parallels the axis of the lever.

Negative Spring Gradient: In some holding or latching toggle devices a large force is often desired when the mechanism is at rest. If conventional positive-gradient springs are used, even greater force must then be overcome to actuate the mechanism. However, if a negative-gradient spring is used, the latching force will be the greatest force exerted by the spring. Springs of this type, which have negative gradients during a short range of their initial deflection, were covered in an earlier article (May 16, 1957, p.144).

They Say . . .

"Problems and purposes which affect modern engineering spread wide across the world, and engineering itself lies in a broad spectrum of thought. At one end it merges with science. It extends through the detailed technical phases and on to the administrative, where we find it impinging upon many areas of government."—J. F. CALVERT, *Head, Electrical Engineering Dept., University of Pittsburgh.*

Take two cylinders of equal diameter—
one rubber-covered, the other all-metal.
Press them together, and have one drive
the other by friction.
Will the surface speeds be the same? No.
But which cylinder will turn faster?
Here's the strange case of the . . .



Rolling Radius of Rubber-Covered Cylinders

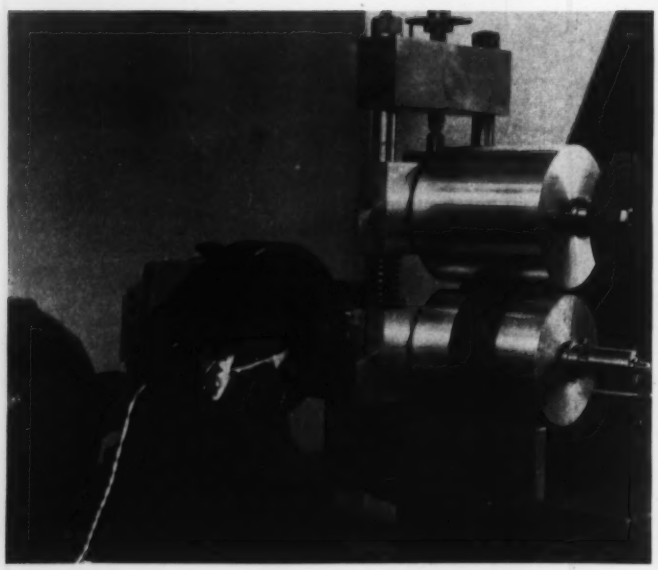
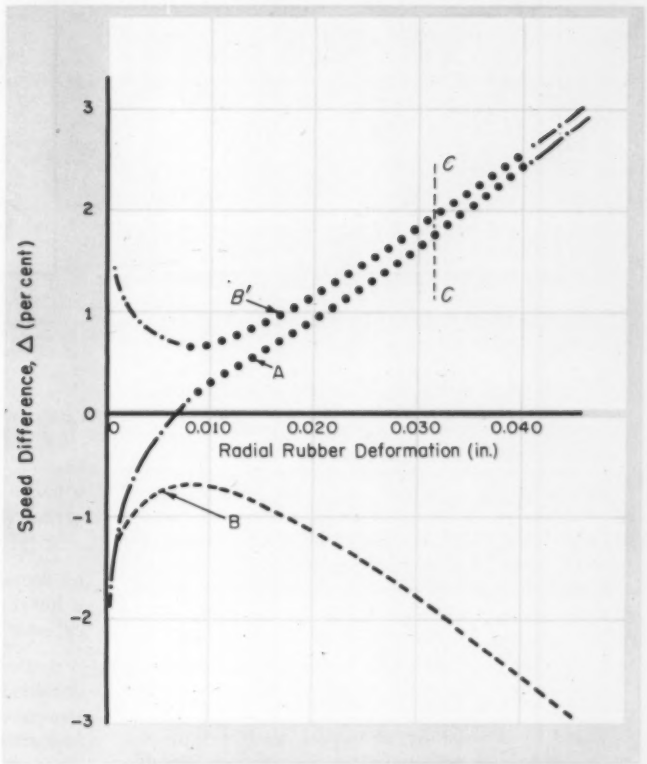


Fig. 1—Apparatus used to investigate the effective rolling radius of cylinders covered with solid rubber. Front bearing support rigging is identical to rear support rigging shown. A shielded neon lamp and disc for measuring drive-shaft speed are mounted in front of the gear box.

Fig. 2—Actual curves for rubber-covered cylinder. Curve *A* shows results for the rubber-covered cylinder driving, curve *B* for the all-metal cylinder driving. Rubber layer was 0.551 in. thick and 2 in. long. Curve *B'* is the mirror image of curve *B*.



H. A. BORCHARDT
School of Mechanical Engineering
University of New South Wales
Sydney, Australia

ROLLS or wheels covered with rubber seldom show an effective rolling radius under load equal to the nominal radius. A pneumatic-tired wheel rolls with an effective radius smaller than the nominal because of deformation.* In marked contrast, a cylinder with a solid-rubber layer performs as though its rolling radius is larger under load than with no load.

When equal-diameter all-metal and rubber-covered cylinders are pressed together, with one driving the other by friction, the surface speed of the rubber-covered cylinder is less than that of the metal cylinder. Outside diameter of one of the cylinders must be altered to produce a common surface speed.

This article reports the results of an experimental investigation, Fig. 1. Special cylinders, both all-metal and rubber-covered, were finished to a diameter of 6 in. Tests were run with the all-metal cylinder friction driving the rubber-covered cylinder, and then repeated with the rubber-covered cylinder driving. Driving speed was approximately 50 rpm.

*G. Temple—"The Dynamics of the Pneumatic Tyre," *Endeavor*, Vol. 15, No. 60, October, 1956, pp. 200-205.

Thickness, axial width, hardness, and deformation of the rubber layer were varied to determine their effects.

Test Results: With a rubber-covered cylinder tested alternately—driving and driven—two sets of speed difference readings were obtained as a function of deformation. Typical results are plotted in Fig. 2 where

$$\Delta = \frac{s - S}{S} 100$$

and Δ = speed difference in per cent, s = driven-cylinder speed, and S = driving-cylinder speed.

Curves shown are part of a family of curves that would be obtained when the second variable is either axial width, radial thickness, or rubber hardness.

When the rubber-covered cylinder is the driver, curve *A*, the all-metal cylinder rotates faster than the driver after deformation is sufficient to overcome slippage. When the all-metal cylinder is driving, curve *B*, the rubber-covered cylinder rotates slower

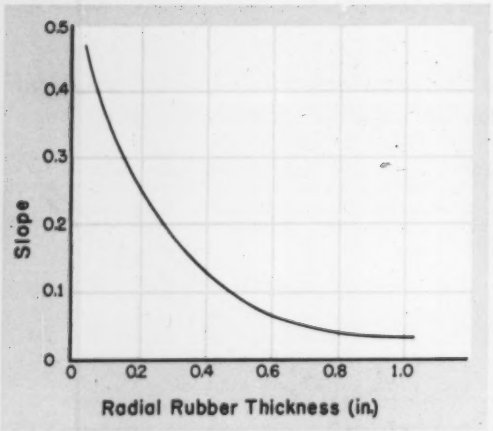


Fig. 3—Slope of linear portion of curves, such as those in Fig. 2, as affected by radial thickness of rubber layers.

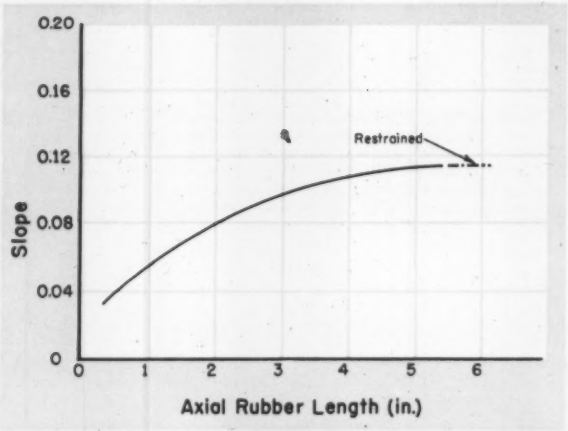


Fig. 4—Slope as a function of axial length of rubber layers.

than the driver. In this case, the greatest speed differences are for small values of deformation where slippage occurs and for large values of deformation where "creep" becomes appreciable.

Negative values of curve *B* are replotted as positive for comparison with curve *A*. At high values of deformation, curves *A* and *B'* are close and approximately parallel. The approximate beginning of this straight-line relationship is indicated by line *C-C*.

Thus, in the family of curves, each set of two curves obtained by changing the second variable will have a different slope, or ratio of speed difference to deformation, for its straight-line portion. For convenience the different values of this slope are used to plot comparison curves for the second variables.

When the radial thickness of rubber is varied, Fig. 3, the value of the slope becomes smaller and approaches zero for increasing rubber thickness. When rubber thickness decreases, the slope tends toward infinitely large values.

In Fig. 4 the slope approaches zero or a small positive value as axial rubber length decreases. With increasing rubber length the slope reaches a maximum, finite value. To prove this result, a narrow rubber strip was restrained by collars clamped to the cylinder. Testing then showed the slope value was increased and reached approximately the same value obtained by the cylinder having the longest axial rubber length.

Effect of rubber hardness upon the slope was found to be negligible. Temperature rise due to rubber deformation was measured but found to be only one or two degrees.

Conclusions: Although the data were not comprehensive, definite trends can be established. They are:

1. A solid-rubber covered cylinder driven by an all-metal roller of the same outside diameter has a lower average surface speed than the driving metal cylinder.

2. A solid-rubber covered cylinder driving an all-metal cylinder of the same outside diameter has a lower average surface speed than the driven metal cylinder.

3. Per cent of speed difference as a function of deformation of rubber surface approximates a straight-line relationship for higher values of deformation.

4. The slope of the straight line approaches zero for increased radial rubber thickness and infinity for decreased thickness. Slope approaches a finite limit for increased axial rubber length and zero for decreased length. Slope remains nearly constant for different rubber hardnesses.

They Say . . .

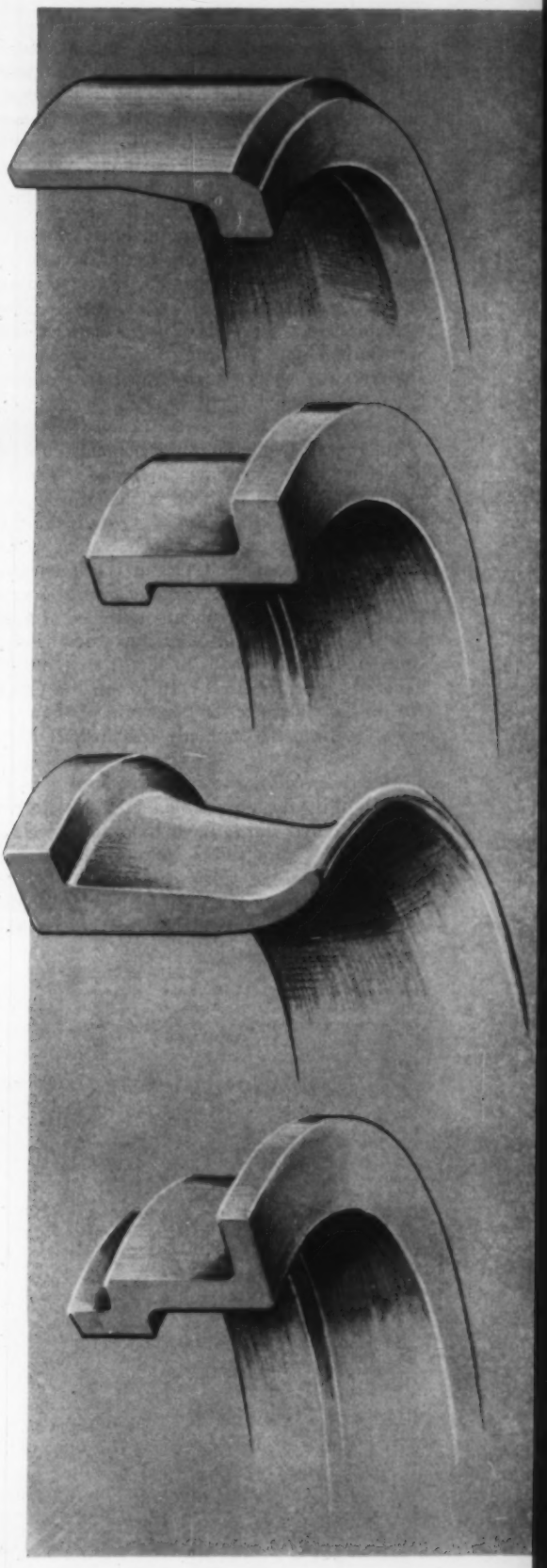
"There are some who would have us believe that advancing technology and the ability to obtain information and conduct operations by remote electronic means, negate the requirement for man's presence on the scene. I do not agree. Man's ability to reason—his judgment—his power of decision—and the professional approach, will always be necessary for optimum effectiveness."—Gen. Curtis E. LeMay, *Vice Chief of Staff, USAF.*

"Engineers—I refer solely to their intellectual activity—are a virile and lusty body of men, with a marked propensity for cross-fertilization, and political economy is not alone among the new sciences, which sprang from the old schools of moral and natural philosophy, in the enrichment it owes to the attentions of roving engineers."—Sir Arnold Plant, *Professor of Commerce, London School of Economics, University of London.*

Design and application of

FLASH BUTT-WELDED RINGS

FORREST W. JOHNSON
Quality Control Mgr.
The American Welding & Mfg. Co.
Warren, Ohio



SEVERAL major advantages can be gained by specifying flash butt-welded rings for applications requiring circular components. Because these rings are usually made from conventional bar stock of square, round, or rectangular cross section, or from special mill-rolled and extruded shapes with near-finished dimensions, savings in material and machining costs are considerable. This is especially significant when expensive alloys are required. Also, the basic forming process for developing a welded ring is less complicated and expensive than forging or casting.

Fabrication: Ring forming is accomplished in one of two ways. The bar stock or special mill shape is bent into a circular form on a three-roll bender or is formed, arc by arc, in special dies. Rings from 5 to 96 in. in diameter are thus produced.

Ends of the ring are joined by flash welding with heat and pressure alone. No additional filler material is required, and pressure used forges the weld area. Strength of the welded joint is generally within 97 per cent of the parent metal and ductility

within 60 per cent. After the ring has been heat treated, no weld seams are detectable at the joint.

Formed and welded rings are sized to a true, circular shape by either expanding them from within or shrinking them from without. Supplemental operations of flattening, final expanding, heat treating, tempering, and cleaning are then performed.

The maximum cross-sectional area that can be flash welded depends on the material composition of the ring and on the ratio of section area to ring diameter. Reducing the diameter correspondingly reduces the area that can be welded. Generally, weldable cross-sectional sizes for various materials are: Carbon steel, 30 sq in.; stainless steel, 16 sq in.; aluminum, 4 sq in.; high-temperature alloys, 8 sq in.; and titanium, 6 sq in.

Tolerances: Dimensions and nomenclature peculiar to welded rings are shown in Fig. 1. The face dimension of a ring is the axial length, or width, of the shape as shown. Gage of a ring is the thickness of the bar stock used and is equivalent to half the difference between the OD and ID dimensions.

Diameter tolerances include ovality, or out-of-roundness, which is frequently specified as a separate tolerance dimension in other industries. For typical rings from 15 to 40 in. in diameter, tolerances are generally specified as ±1/16 in. on the OD or ID. An off-flat tolerance, or departure of the ring from a flat surface, is commonly specified as 1/16 in.

Materials: Alloys shown in the chart do not represent all of the flash-weldable materials. Rather, they are the alloys which have been flash welded successfully in production quantities by American Welding and Mfg. Co.

Heat treatments of a flash butt-welded joint are as numerous as those available for the parent metal. Physical properties of the welded joint are equally responsive to the specified heat treatment.

Design Considerations: For flash butt-welded rings, allowance must be made during design for:

1. Change of rectangular cross sections due to forming and sizing. Section size is a function of gage-to-face ratio and ring diameter.
2. Changes in gage.
3. Out-of-round and out-of-flat tolerances.
4. Minimum stock removal for metallurgical reasons.

Bar stock is usually selected for rings if the specified material is of a low base price and is easy to machine. It is also selected when quantities are so small that the cost of mill extrusion dies and special tooling for forming, welding, and sizing may exceed the expected gain in material savings. Or, use of bar stock may be indicated if the material specified is not available in a particular section shape because of size or physical properties. Since standard tooling is used for forming, welding, and sizing rings made from bar stock, an economical end product is the result.

Mill-rolled shapes are specified when the quantity of rings is sufficient to absorb the cost of rolls and special tooling required for forming, welding, and sizing the rings. The economy of selecting a mill-rolled shape is largely determined by the cost of the material. Not only should the savings in material be considered when selecting a special shape, but also the savings in reduced machining time which can be substantial.

Extruded sections may be indicated when quantities do not justify mill roll charges. However, base price of the material must also be considered. Extruded sections are economical when section weight exceeds approximately 3 lb per ft and the maximum section dimension is under 10 in. Extrusions offer a slight additional advantage over mill-rolled sec-

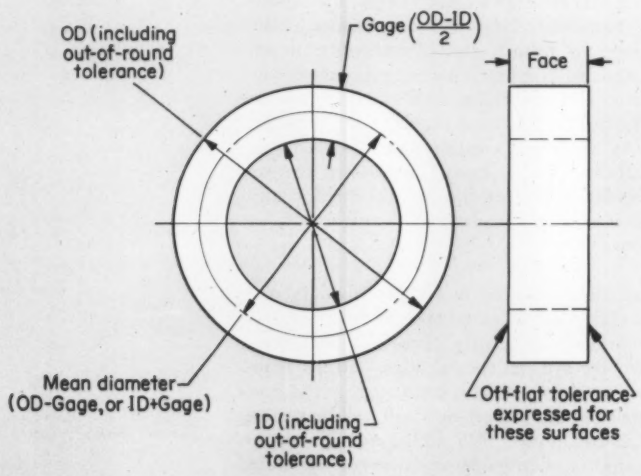


Fig. 1—Dimensions and nomenclature for flash butt-welded rings.

FLASH-WELDABLE ALLOYS

Material	Applications
Martensitic and Austenitic Age-Hardenable Alloys	
403-410	Steam turbine and gas turbine blades, jet-engine parts
Greek Ascoloy	Jet engine parts, steam and gas-turbine parts
440C	Bearings, valve seats, shafts, pump parts, balls
17-4 PH	Gears, cams, springs, shafts, aircraft parts, hardware
17-7 PH	Springs, aircraft structural parts, pressure tanks
Inconel X	Aircraft gas-turbines, rotor wheels, blades, vanes
Timken 16-25-6	Gas turbines, turbo-superchargers, jet-engine wheels and buckets
Discaloy	Gas-turbine rotors, bolts, jet-engine parts
Tinidur A-286	Jet-engine bands, bolts
AM-355	Valves, springs, aircraft parts
Hastelloy C	Refinery equipment, jet-engine parts, heat-treating equipment
Hastelloy B	Refinery equipment, valves, pumps, turbine blades and wheels
Multimet N-155	Rotors, turbine wheels, blades, aircraft parts, tail cones, afterburner rings, rocket parts
Inconel 700	Jet engine parts, gas-turbine blades
Inconel 702	Combustion liners, transition pieces between combustion chamber and turbine
Incoloy 901	Aircraft and industrial gas-turbines, turbine rotors, compressor discs
Hastelloy R235	Turbine blades, airframe skins, jet-engine parts
Rene' 41	Jet-engine parts, airframe skins
Waspaloy	Gas-turbines, jet-engine buckets, blades, rocket-engine parts
M-252	High-temperature bolting, turbine buckets, wheels
Unitemp 212	Jet engines, gas-turbines, rocket and missile parts
Lapelloy	Steam-turbine buckets, compressor blades, valve stems
USS Stainless W	Cams, bearings, valves, aircraft parts
PH-15-7Mo	Springs, jet-engine parts, pressure tanks
M-308	Aircraft gas-turbines, jet-engine parts
USS 12Mo-V	Aircraft and guided-missile parts
Inconel W	Gas-turbine blades, jet-engine parts
Nimonic 90	Aircraft parts, marine parts, combustion chambers, rotors, discs
K Monel	Ball bearings, springs, pump shafts, low-temperature parts, marine equipment
Medium Tensile Strength, Low-Alloy Materials	
Chromoloy	Aircraft gas-turbine and jet-engine parts
Timken 17-22(A)S	Bolting, flanges, discs, fittings, dies
Maxel 2B	Spindles, feed screws, shafts, axles, racks, spring clips
NAX	Gas-turbine structures
USS T-1	Pressure vessels, missile components, tension rods
B1113	Excellent machinability and surface finish. Not recommended for vital parts.
C1117	Carburizing grade for free machining
Armco Ingot Iron	Magnetic controls, generator and motor frames, electromagnetic casings
Carbon Steel	General use in construction and fabrication
E3310	Aircraft gears, piston pins, chain bushings, ratchets, cams
Commercially Pure Titanium and Titanium Alloys	
RC A-70, Ti-100, MST-111	Airframe and engine parts, wheels, blades, vanes
Ti-140	Jet-engine compressor components
RC C-130 AMo	Airframes, jet engine parts, industrial equipment requiring strength and corrosion resistance
C-120 AV	Jet-engine components, airframes, special ordnance equipment
Ti-150A	Jet-engine discs and blades, compressor parts
A-110 AT	Airframes, jet-engine components, equipment requiring strength and corrosion resistance
C-140 AMo	Jet-engine discs, blades, airframe parts
Ti-110	Airframes, jet-engine components
High Tensile-Strength, Low-Alloy Materials	
8630	Pinions, gears, housings, shafting, airframe parts
8740	Gears, pinions, shafts, bolts, casings, axles, housings
4340	Gears, pinions, shafting, bolts, casings, missile cases
4130	Fittings, bushings, gears, shafting, aircraft frames, missile cases
4140	Gears, shafts, axles, machine-tool parts
52100	Bearings, tools, punches, bushings, bearing races
4337	Flanges, fittings, gears, shroud rings, crankshafts, pressure vessels
4140 Pb	Low-alloy applications where better machinability is needed
4130	Gears, shafting, axles, valve seats, clutch parts
USS Strux	Airframe parts, missile and rocket components
Vasco Jet 1000	Jet airframes, landing gears, missile components
Unimach No. 2	Landing gears, aircraft components, missile parts, dies
Thermold J	
Tricent	Airframe parts, missile and rocket components
Super Tricent	Airframe parts, missile and rocket components
Graph-Mo	Dies, punches, cams, bushings, mandrels
Austenitic and Ferritic Nonhardenable Alloys	
430	Jet parts, food-processing equipment, tanks
321	Jet parts, superheaters, high-pressure pipe, boiler tubes
347	Radiant tubes, exhaust tubes, high-pressure steam pipe
304	Chemical equipment, jet parts, cooling coils, evaporators
316	Acid handling equipment, jet parts, chemical tanks
309S	Furnace parts, heat-treating fixtures, aircraft parts, chemical equipment
310	Furnace parts, heat-treat fixtures, gas turbines, jet-engines
314	Furnace parts, radiant tubes, heat-treat fixtures, jet parts
Inconel	Food-processing equipment, jet-engine parts, furnace parts
TPA	Exhaust valves, jet components
19-9DL	Jet-engine parts, exhaust manifolds, guided-missile parts, tail cones
19-9DX	Jet engine buckets, tail cones, exhaust manifolds, guided-missile parts
Hastelloy X	Jet afterburners, high-temperature furnace parts
Hastelloy W	Welding electrodes, jet-engine parts
L-605	Gas-turbine rotors, buckets, jet-engine components
Incoloy T	Furnace parts, heat-treat fixtures, jet parts, combustion liners
304-1% B	Neutron shields, control rods, atomic applications
Hastelloy F	Chemical equipment, jet-engine parts
Aluminum Alloys	
2017	Screw-machine products, fittings, structural applications
2024	Aircraft structures, fittings, rivets, struts, fasteners
2014	Rivets, structural fittings, aircraft and engine parts
6061	Aircraft framing, structures, marine applications
7075	Aircraft structures, mobile equipment
6063	Molding and trim, portable irrigation systems, architectural applications
6066	Gas engines, general structures, rails
Magnesium, Zirconium and Copper-Base Alloys	
AZ-31	Parts requiring rigidity, medium strength, and low density
HK-31	Missile and jet-engine components, atomic applications
HM-31	Missile and jet-engine components, atomic applications
Bearing Bronze	Bearings, gears, sleeves, bushings, pipe fittings
Zircaloy No. 2	Nuclear reactors, fuel elements, piping, plant equipment, pumps, valves

tions in that roll draft and clearance need not be considered.

Precision Rings: One of the newest developments in the welded-ring field is the production of precision rings which require little or no machining. These rings are made from cold-rolled or drawn stock to exacting tolerances. Often, the simplicity of a design, availability of material, and other specifications dictate their use. When the end product is to be used with little or no machining, additional design considerations are necessary. Allowance must be made for:

1. Section changes due to forming.
2. Dimensional adjustments to the finished section to define a cold-rolled or drawn section.
3. Hardness control of the finished section for uniform forming response.
4. Metallurgical factors which influence later heat treatment since distortion cannot be tolerated in these rings.

Used alone or in combination with other components to form assemblies, flash butt-welded rings offer a versatile and economical approach to the design of circular components.

Less Material = Less Cost

Flash Butt-Welded Rings Versus Castings: Money and material savings were considerable when a ring, formerly cast, was produced by the flash butt-welding process, *a*. Weight of the original casting was 490 lb. Fabricating the ring from bar stock saved 130 lb of material which reduced the cost by approximately 43 per cent.

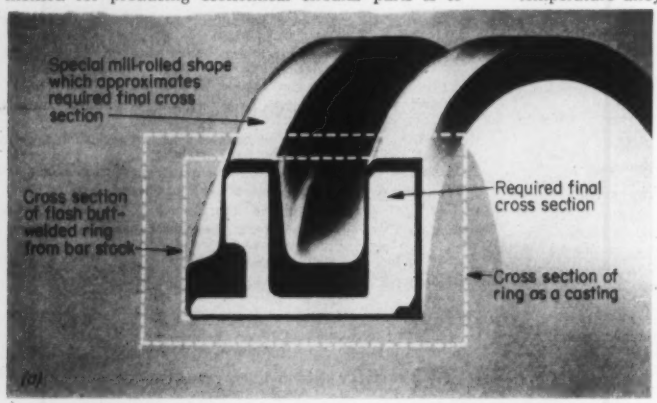
Choice of a special mill-rolled section which most nearly approximated the required cross section, reduced the weight of the ring to 286 lb, or 222 lb less than the original casting. Manufacturing cost was approximately 57 per cent less than that of the cast ring. Compare the obvious difference in required stock removal for each of the three choices of fabrication.

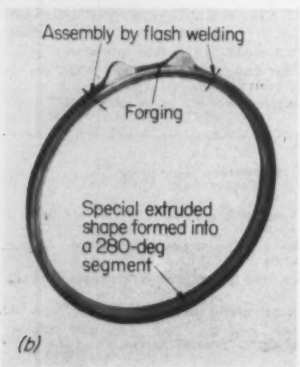
Combining Welded Rings and Forgings: One unique method for producing economical circular parts is to combine flash-welded rings and forgings. The stainless-steel jet-engine part, *b*, was originally made from a rectangular bar which was formed and flash welded. Considerable machining was required on the ID to produce the flange.

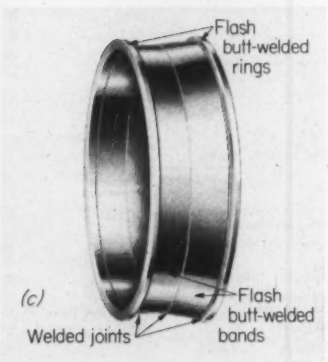
A change was made from bar stock to an extruded section which approximated the flange. By combining this section (formed into a 280-deg segment) with a forging by flash welding as shown, a 72 per cent saving in material was realized. Cost of each ring was cut in half.

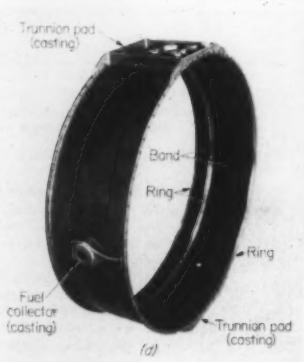
Ring Assemblies: Flash butt-welded rings can be used in combination with each other or with sheet-metal stampings, castings, spinnings, and other components for producing assemblies. The aircraft casing of a high-temperature alloy, *c*, consists of four flash-welded rings joined by submerged-arc welding after the weld area was prepared by machining. The assembly weighs 340 lb, or 490 lb less than the same casing made as a forging. Machining time was drastically reduced.

The 36.5-in. diam turbine-casing assembly, *d*, combines three welded rings and two light-metal bands with castings. The rings, formed from bar stock and machined, were joined to the 0.090-in. thick bands by inert-arc welding. The castings —two trunnion pads and a fuel collector—were welded to the circular assembly. The assembly was stress relieved prior to final machining.


Special mill-rolled shape which approximates required final cross section
Cross section of flash butt-welded ring from bar stock
Required final cross section
Cross section of ring as a casting
(a)







Nomogram gives maximum force acting on

GENEVA DRIVE ROLLERS

CHARLES TIPLITZ
Chief Engineer
Chalon Consulting Engineers*
Cedar Grove, N. J.

DESIGNING for life or strength of the driving roller or pin in a Geneva mechanism, Fig. 1, should be based on the maximum force acting on the pin. This force depends upon dynamic loads resulting from acceleration and inertia of the driven system.

To help simplify necessary calculations, this article presents a nomogram, Fig. 2, for determining the maximum force. It can be used for a wide range of these parameters: Geneva size, number of stations, speed of operation, and driven inertia.

Example: Assume that a three-station Geneva indexes a turntable at 30 stations per minute. That is, driver speed $N = 30$ rpm. Turntable and

*Consultants for Eisler Engineering Co., Newark, N. J.

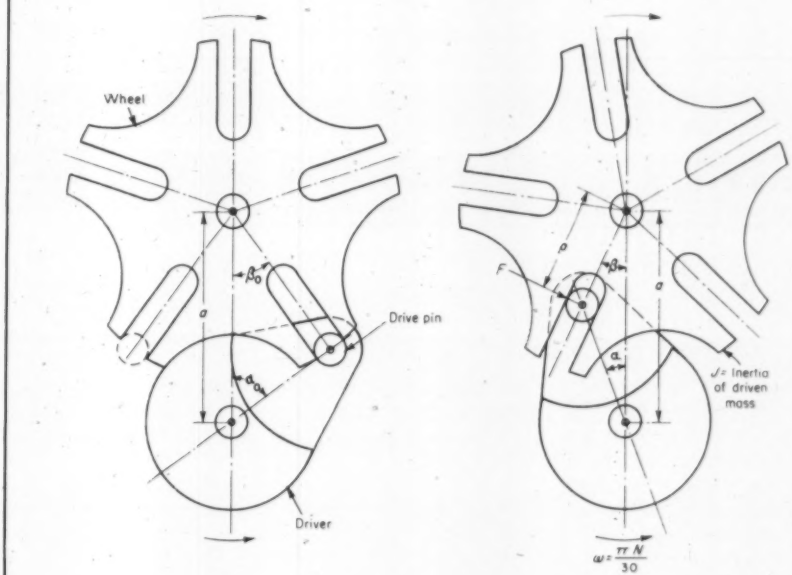


Fig. 1—Geometry and nomenclature for Geneva mechanism.

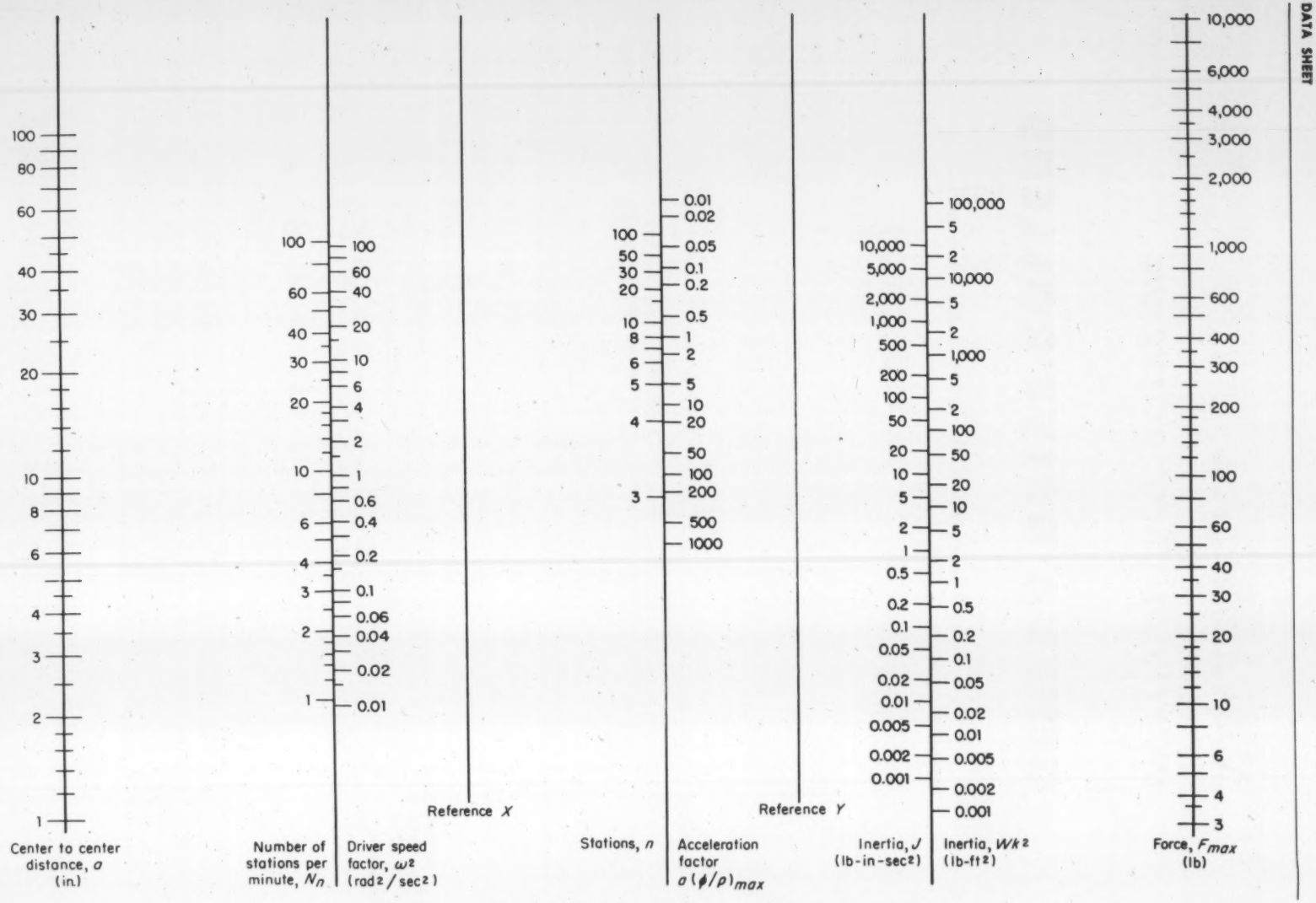


Fig. 2—Nomogram for finding maximum force on driving pin or roller of a Geneva mechanism.

wheel have an inertia of $Wk^2 = 0.8$ lb-ft², and the center-to-center distance a between the driver pivot and Geneva wheel is 5 in. Fig. 3 shows the route through the nomogram.

First, draw a line from 5 on center-to-center distance scale a, to 30 on stations-per-minute scale N_n, and extend the line to Reference X. From this point draw a line through 3 on stations scale n, and extend the line to Reference Y. Finally, draw a line from this point through 0.8 on inertia scale,

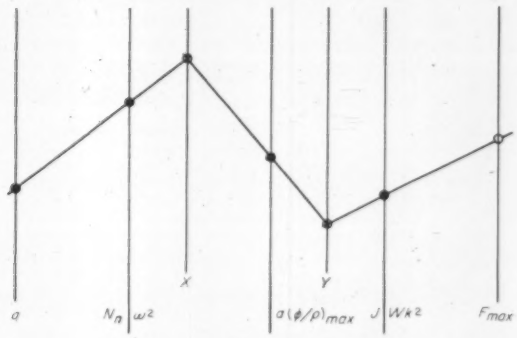


Fig. 3—Key to nomogram, Fig. 2

Wk^2, and extend the line to force scale F_{max}. The answer on the force scale is 130 lb.

Theory: The basis for the nomogram is the equation for maximum force acting on the pin:

$$F_{max} = J\omega^2(\phi/\rho)_{max} \qquad (1)$$

Where $\phi = d^2\beta/d\alpha^2$, a measure of angular acceleration, and ρ is introduced to account for the radius at which the force is applied.

From the geometry of the Geneva mechanism,

$$\rho = a(1 + \sin^2\beta_0 - 2\sin\beta_0\cos\alpha)^{1/2} \qquad (2)$$

Effect of angular acceleration in the mechanism is accounted for by

$$\phi = -\frac{\sin\beta_0\cos^2\beta_0\sin\alpha}{(1 + \sin^2\beta_0 - 2\sin\beta_0\cos\alpha)^2} \qquad (3)$$

Hence, the ratio ϕ/ρ is obtained by combining Equations 2 and 3:

$$\frac{\phi}{\rho} = -\frac{\sin\beta_0\cos^2\beta_0\sin\alpha}{a(1 + \sin^2\beta_0 - 2\sin\beta_0\cos\alpha)^{2.5}} \qquad (4)$$

Force on the pin is maximum when the derivative of Equation 4 is zero. If this derivative is set equal to zero and the resulting equation solved for α,

$$\cos\alpha = -\frac{1 + \sin^2\beta_0}{6\sin\beta_0} + \left[\left(\frac{1 + \sin^2\beta_0}{6\sin\beta_0}\right)^2 + \frac{5}{3}\right]^{1/2} \qquad (5)$$

The maximum force is obtained by using Equation 5 to solve Equation 4, and substituting the result in Equation 1. In the nomogram, acceleration factor $a(\phi/\rho)_{max}$ is dimensionless; it is the right-hand side of Equation 4, cleared of center distance a.

Differences in force values obtained using this method of solution and the less rigorous method of maximizing the torque on the pin[1,2] are within the usual accuracy requirements acceptable in strength analyses.

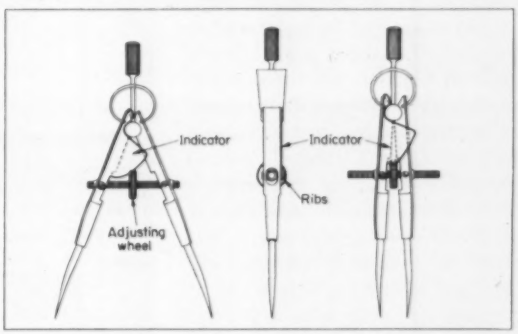
REFERENCES

1. Otto Lichtwitz—"Mechanisms for Intermittent Motion," MACHINE DESIGN, December 1951, pp. 134-148.
2. Ray C. Johnson—"How to Design Geneva Mechanisms," MACHINE DESIGN, March 22, 1956, pp. 107-111.

Tips and Techniques

Indicator Simplifies Line Division

Usefulness of an adjustable divider for subdividing lines into equal spaces can be improved by adding an indicator to the adjusting wheel. Made of a thin-gage material, one end of the indicator fits into the tension spring groove, and the other end is secured to leg of divider with swivel screw. The indicator is cut in the shape of a quarter ellipse so that the indicator clears the adjusting wheel by about 1/32 in. regardless of the divider setting. The indicator is not marked; the ribs on the adjusting wheel are used as division marks. The indicator does not hamper use of dividers in any case.

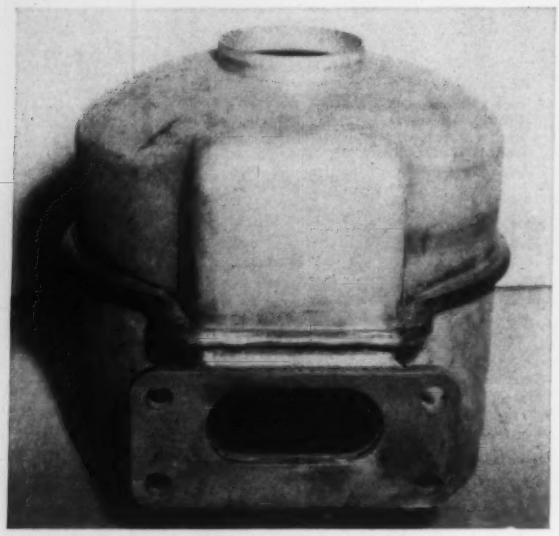


In use, the divider is set as accurately as possible and the required spaces are stepped off. If the distance stepped off is too long or too short, the divider is opened or closed the required amount, and the number of ribs on the adjusting wheel that pass the indicator are counted. The divider can then be adjusted by adding to or subtracting from the initial setting the quotient equal to the number of ribs passing the indicator divided by the number of subdivisions.—CHARLES E. BELSHE, *development engineer, Trailmobile Inc., Springfield, Mo.*

Lincoln

WELDYNAMICS

NEWS ABOUT ARC WELDING AT WORK CUTTING COSTS



Arc-welded pressed-steel assembly, left, weighs only 11½ lbs.; iron casting formerly used, right, weighed 26¼ lbs.

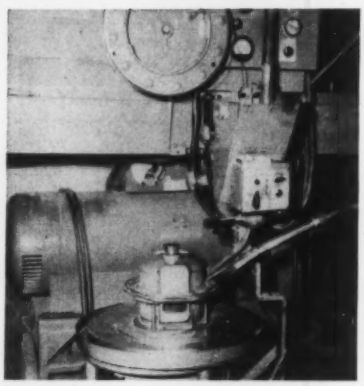
White spots on the casting are blow holes that were repaired by cold-soldering.

REDESIGNED FOR WELDING, AIR CLEANER COSTS 36% LESS

Reduction in weight of 56 pct, unit cost saving of 35.8 pct and a cut in manufacturing rework from 25 pct to 3½ pct; all three were realized by a change from cast iron to arc-welded pressed steel air cleaners for Caterpillar construction and mining equipment.

The cleaners are basically a 9-in. diam. cylindrical body attached to a central cover shell carrying a mounting flange and a top dome or cover with a 2½ in. neck for the intake tube. Originally the two elements of the dome were made as a casting weighing 26¼ lbs. Connections to the center tube and lower body were soldered, which required first dip-tinning the casting.

Leaks in the soldered joints, along with pinholes and porosity in the casting after machining, ran as high as 25 pct during 10-lb. air pressure testing; subsequent cold-soldering repairs had to be made. Beyond this, breakage of castings in handling and transporting often ran up to 5 pct.



Cover halves clamped in fixture are rotated under LINCOLNWELD submerged-arc welding head. The 34-in. weld takes 30 seconds.

In the redesign, the dome shells are formed from 2 flat blanks of 12 gauge steel. After trimming and punching, they're welded automatically on a Lincolnweld submerged-arc automatic welder.

DESIGN AIDS AVAILABLE

The new 11th edition of "Procedure Handbook of Arc Welding Design and Practice" has 240 pages on Machine Design. An authoritative work, the "Procedure Handbook" is written to help the machine designer achieve the most efficient use of welded steel. The price is $3.00, $3.50 outside the U.S.A. The book may be ordered from The Lincoln Electric Co.

Machine Design Seminars are conducted regularly at the Lincoln plant. Write for dates and information.

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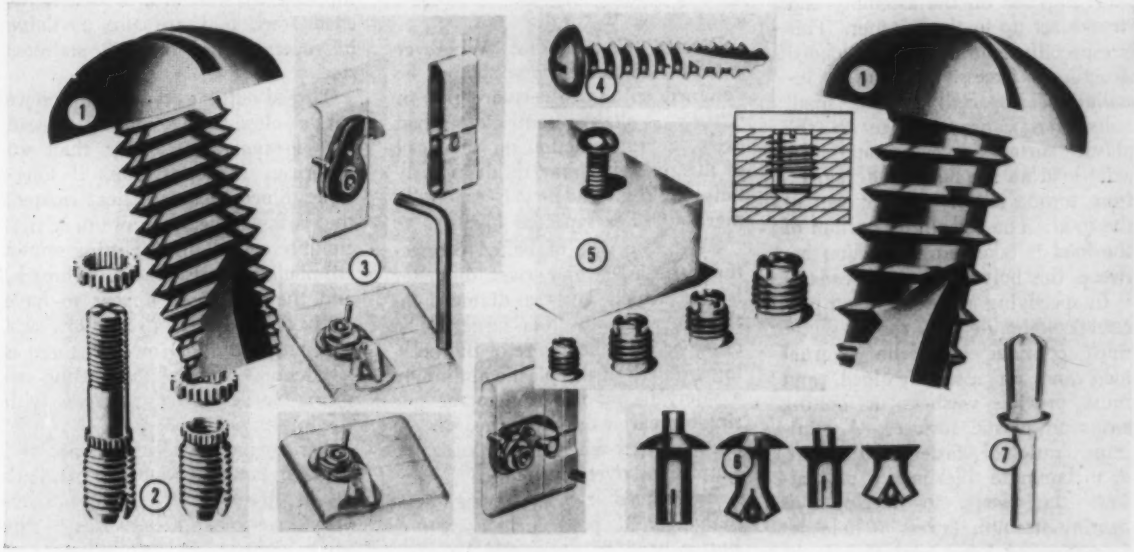

1. Self-tapping screws of the thread-cutting type. 2. Self-threading inserts; stud, left, internal tapped hole, right. 3. Quick-release fastener for sandwich laminates. 4. Self-drilling screw. 5. Self-tapping inserts. 6. Aluminum drive-rivets (Type 2S or 56S aluminum preferred). 7. Corrosion-resistant plastic drive-rivet.

Fasteners for Glass-Reinforced Plastics

MARSHALL D. WEISS
Project Engineer
Owens-Corning Fiberglas Corp.
Ashton, R.I.

MECHANICAL fasteners are often the only solution to problems of assembling glass-reinforced plastic parts. These fasteners are feasible for access doors, cover plates, parts requiring replacement or removal for repair, joints subject to complex loadings, and for joining parts having dissimilar thermal expansions.

Advantages of mechanical joints include utilization of metalworking tools and techniques, ease of inspection, utility of repeated assembly and disassembly, and simplicity of design. Disadvantages include cost, weakening and damaging of the plastic, and the necessity of additional operations for assembly.

While rivets, screws, and bolts may all be used, it is often necessary to modify conventional joint designs to achieve desired results. This is because the lack of ductility of glass-reinforced plastics is responsible for concentration of local stresses, which results in unequal load-distribution properties. Also, the lower values of shear and bearing strength of the plastic make it necessary to design these joints more carefully than comparable metal joints.

Punching and Tapping: Because of shrinkage of the plastic, it is necessary to specify a punch diameter which is oversize by 4 to 5 per cent of the plastic thickness. The smallest hole to be punched should be a minimum of 75 per cent of the laminate thickness. Sharp edges can be obtained on holes punched in laminates to 3/32 in. thick. Quality in thicknesses to 5/32 in. is fair, and to 1/4 in., holes are rough but clean.

Maximum accuracy obtainable in a tapped hole in glass-reinforced parts is a Class 2 fit with a 75 per cent thread. For most fastening applications, this is adequate. Where a more precise fit is required, inserts are generally used.

Tap drill holes should be smooth and somewhat larger than is customary for metals. The oversize hole provides 75 per cent of full thread which results in a cleaner job. In blind holes, the tap drill should go in deep enough to provide a minimum clearance of three threads. Before beginning tapping, the edge of the hole should be chamfered slightly.

Bolted Connections: Selection of a threaded fastener is governed by loads imposed on the assembly and stresses set up in the fastener. This is especially true in heavily loaded structures. Excessive torque at installation, especially with small bolts, can cause damage to the plastic surfaces even though the axial load on the fastener developed from torque is only 10 per cent of the total. The remaining portion of the load is taken up in friction between the bolt and nut threads.

In specifying a fastener for a particular joint design, the designer must consider both the external load and an assembly load, and must provide washers or bolting strips on plastic surfaces. A minimum ratio of fastener diameter, d, to laminate thickness, t, of 1 allows the plastic to develop full bearing strength (stress at hole deformation of 4 per cent of bolt diameter). At d/t ratios of $\frac{1}{2}$ ($\frac{1}{4}$-in. laminate and $\frac{1}{8}$-in. bolt), it is possible to shear the fastener before failure occurs in the plastic.

Holes should be drilled or reamed 1/64 in. larger than the bolt diameter and must be well aligned. Misalignment tends to set up considerable stresses when the fastener is inserted, and the joint may not prove serviceable.

Spacing: At small edge distances, failure of a joint usually occurs through shear at ends, or failure in tension at the net section before the laminate has developed full bearing strength. Considerable concentration of stress develops at the hole, and stresses at the net section are but a fraction of the tensile strength of the laminate. Therefore, in design, it is not correct to base the load-carrying capacity of the net section on its area and tensile strength of the plastic. Effects of notch sensitivity must be taken into account. These factors are about $3\frac{1}{2}$ times the average stress.

Mat laminates, because of random arrangement of fibers, are equally susceptible to stress concentration at a hole in all directions of loading. Fabric laminates show less notch sensitivity at holes when the load is applied in the direction of warp. Mat laminates, therefore, require the greatest edge distance in spacing. An edge-distance ratio of 4.5 diameters and side-distance ratio of $3\frac{1}{2}$ diameters appear to be adequate for all directions of loading.

Riveted Connections: Wherever possible, riveted joints should be designed so that rivets are not in tension. A slight eccentricity of load exerts a prying action on the head of the rivet that may result in early failure. This tendency is especially marked under repeated loading.

As in the case of bolted connections, a satisfactory rivet diameter is one which gives a diameter-to-thickness ratio of 1 or larger. The designer must be aware of the bearing strength of the plastic and apply a safety factor of 3 to 4 to the safe single-shear value for the size of rivet selected when determining the number of rivets desired.

Truss-head rivets, having head diameters 31 per cent larger than button-head types, should be used. The larger area provides better load distribution over the surface. A desirable rivet length is 1 diameter plus the thickness of the parts joined including washers. Rivet lengths should be determined by experiment, and an overlong rivet should be favored rather than one which is too short.

Holes should be large enough to permit easy and rapid assembly of rivets but should not be so large that they permit excessive bulging or buckling. This might result in bent or eccentric upsets and loose rivets which cause a loss of strength of the joint. A hole 1/64 in. larger than the rivet diameter is adequate. For a stress-concentration factor of 3, a recommended edge distance of $4\frac{1}{2}$ diameters and a side distance of $3\frac{1}{2}$ diameters is adequate for rivet spacing.

Screw Connections: Designers can choose many standard fasteners for various joint designs. Self-tapping screws, particularly, have found wide acceptance in plastic-to-plastic joints, for either a purely mechanical connection or for a combination joint. They are very suitable for holding the adhesive-bonded surfaces of two parts together while the adhesive cures.

Thread-forming types of self-tapping screws form a mating thread as they are driven into a drilled, punched, or molded hole of suitable size. A fastening made with these screws resists vibration, tension, and shear stresses. Screws are supplied as standard in case-hardened steel, and are also available in several types of 18-8 stainless steel.

Thread-cutting types of screws cut a close-fitting mating thread that is somewhat better than an American National Class 2 tolerance. Since these are heat treated, they are stronger than ordinary machine screws. Thread-cutting screws are made in coarse and fine threads, and the two types appear to have equivalent properties in driving and stripping torques. However, there is less tendency to delaminate the entering surface of the plastic with the fine-thread type.

For a given type of fastener and a given laminate, pull-out strength varies directly with fastener diameter since shear area varies in the same manner. For cloth laminates of 56 per cent glass and mat laminates of 37 per cent glass, pull-out strengths are lower with larger pilot-hole sizes. For the lower glass-content mat laminates, there appears to be an optimum pilot-hole size for maximum pull-out strength. If holes are too large or too small, pull-out strength is affected adversely. The lower strength for small pilot-holes is probably due to stresses induced in the plastic in driving the fastener.

Self-Drilling Screws: These are a rather recent development which have not yet gained full recognition. Features of these screws allow the screw to be driven into a laminate without any predrilled holes. The cost savings realized in many fabricating operations with this type of fastener should make it very useful. At present, there is no data available on their pull-out strength, but it is expected to be somewhat lower than for the self-tapping types. The screws are similar to the thread-cutting type with the addition of an off-center cutting edge and a gimlet point.

Machine Screws: Many different types of these fasteners are available in different corrosion-resistant metals and also in thermoplastics. Any of these screws, preferably with coarse threads, may be used for making plastic or metal attachments

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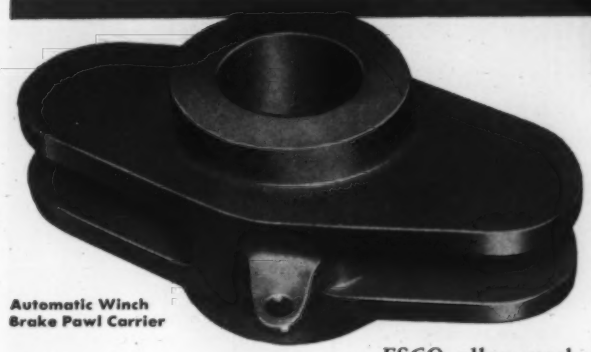

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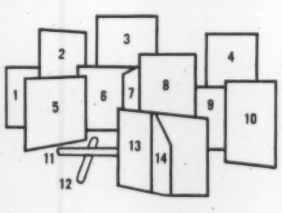

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to glass-reinforced parts. Patented spacer designs are available which may be used when making a plastic connection with one of the parts being tapped. These spacers of thermoplastics, rubber, or metal, prevent damage to plastic surfaces.

Another special screw feature such as an integral washer is most useful when connecting a plastic part to metal. When the surface of the plastic part is not flat, a neoprene washer distributes the load over the full washer area and prevents concentration of stresses.

Inserts: When used in laminates sufficiently thick to accommodate them, inserts provide many advantages. They offer great pull-out strength because of the large shear area in contact with the plastic. The outside diameter of the insert, much larger than the fastener itself, affords increased bearing area. When necessary to remove and replace a fastener frequently, the insert material is able to take the wear on internal threads.

Molded-in-place inserts find better application in parts made with premix molding compounds. If this type of insert is used in parts made with mat or preforms, it becomes a problem to assure adequate reinforcement immediately adjacent to the insert. Many other types of inserts are available which can be installed in the part after molding.

Self-tapping inserts, once installed, become firmly locked in the laminate, and the friction holding the insert in place is sufficient to resist any turning torque normally applied to the fastener. These inserts are generally supplied in case-hardened steel for use in glass-reinforced plastics and are available with various surface treatments for corrosion resistance. Range of available sizes is from No. 4 to ¾-in. internal threads.

A popular form of a self-threading type of fastener consists of a precision-formed coil of diamond-shaped wire. When seated in a specially tapped hole it provides standard-size 60-deg threads that resist wear and can withstand higher loads than equivalent size conventionally tapped threads. Since these threads are flexible, they permit shrinkage of the plastic without cracking around the insert. They are available in stainless steel and other metals in standard sizes ranging from No. 4 to 1½ inches.

Other types of self-threading inserts are machined from solid-steel stock and have external threads. They are generally threaded into a tapped hole with a screwdriver or special inserting tool. Some are provided with locking pins or collars which prevent the insert from turning in the plastic during installation or removal of the screw.

Push-in type inserts are the simplest to use since it is only necessary to press them into place in the proper size hole. They are held fast by knurls, fins, or annular rings on the outer surfaces. When pressed into a hole, axial slots in the insert close causing the internal threaded hole to become tapered. As a screw is driven in, the insert expands and locks firmly into place in the plastic. At the same time, a locking action is exerted on the screw itself.

Stapling: Metal staples driven with portable pneumatic equipment are used by many fabricators. They provide a high-speed, relatively inexpensive method of fastening parts which have suitable flanges. The majority of applications to date are those which require a fastening to supplement an adhesive bond while curing. However, for light load applications, the staple joint itself is adequate without additional fasteners. Equipment is capable of driving and clinching a staple through two plastic flanges ⅛ in. thick or through one ⅛ in. thick plastic part and a metal part 1/32 in. thick.

Quick-Release Fasteners: Many of these fasteners, developed mainly for the aircraft industry, can be applied to reinforced-plastic mechanical joints. They are particularly valuable in applications where it is necessary to engage and disengage panels, for example, and are desirable for components which must withstand vibration. For plastic-to-plastic connections, there is little chance for the plastic to become damaged through stress concentrations on the surface.

SPI paper, "Mechanical Fasteners for Glass Reinforced Plastics," Proceedings of the Fourteenth Annual Meeting of The Reinforced Plastics Division of SPI, Chicago, February, 1959; *Section* 3-*C*, 18 *pp.*

Helpful Literature
for Design Executives

For copies of any literature listed, circle Item Number on Yellow Card—page 19

Teflon Tubing

Full line of CDF extruded TFE Teflon tubing is described and illustrated in Bulletin ET-59. Physical and electrical properties and sizes are tabulated on spaghetti and flexible thin-wall types. 4 pages. Continental-Diamond Fibre Corp., Newark, Del. C

Circle 601 on Page 19

Check Valves

An all-fluorocarbon construction of the fluid surface is featured by Kemlon check valves designed for severe corrosion service. Burst pressures over 1000 psi are available. Dimensions and other data are provided in Bulletin CV-101. 2 pages. Keystone Engineering Co., 6315 England St., Houston 21, Tex. P

Circle 602 on Page 19

Steel Castings

Mechanical properties, analyses, specification designations, and heat treatments on carbon, low alloy, and stainless steel castings are tabulated in this 1959 reference chart. It also reviews briefly services and facilities of this company. 6 pages. Lebanon Steel Foundry, Lebanon, Pa. E

Circle 603 on Page 19

Controlled Finishing

The technique of machining only to the roughest finish consistent with optimum performance is discussed in Brochure ED 21717 entitled "Control the Finish and You Control the Profit." Described is the portable Brush Surfindicator which measures surface finish down to 1 microinch. 12 pages. Clevite Corp., Brush Instruments Div., 3405 Perkins Ave., Cleveland 14, Ohio. G

Circle 604 on Page 19

Interlocking Drawing File

Engineering drawings, tracings, prints, or maps can be stored in quantities from 1 to 30 in each 2½-in. square Hamilton Pack Interlock file. These files interlock to form banks which can fit in any available space. Booklet ADR-518 shows filing arrangements, and gives installation instructions. 8 pages. Hamilton Mfg. Co., Drafting Equipment Div., Two Rivers, Wis. K

Circle 605 on Page 19

Magnetic Servo Amplifiers

Applications for the B line of transistor servo amplifiers cover power control of automated milling machines, lathes, jig bores, camera positioners, computers, optical tracking systems, and inertial platforms. Data deals with 1 to 4-stage systems in descriptive Bulletin S-961. 8 pages. Magnetic Amplifiers, Inc., 632 Tinton Ave., New York 55, N. Y. D

Circle 606 on Page 19

Data Processing System

The Automatic Keysort System for data processing is described as a new concept in practical office automation in Brochure S-500. Piece shows how an original unit record can be coded for automatic processing with flexible low-cost machines. 12 pages. Royal McBee Corp., Port Chester, N. Y. D

Circle 607 on Page 19

Ceramic Standoff Insulators

Physical specs and prices on 14 basic styles of JAN ceramic standoff insulators, in a wide range of sizes, are listed in Form 42-181R3. Over 75 different standoffs are described. 4 pages. Globe-Union Inc., Centralab Div., 900 E. Keefe Ave., Milwaukee 1, Wis. K

Circle 608 on Page 19

Electronic Air Cleaner

The high-velocity Electro-Cell electronic air cleaner is described as to operating principle, collector cell constructions, design features, maintenance, power pack, specifications, dimensions and capacities in Bulletin 258A. 16 pages. American Air Filter Co., Louisville, Ky. G

Circle 609 on Page 19

Adjustable Speed Drive

Redesigned Ajusto-Spede drive made in ¾ to 7½ hp ratings supplies precise operating speeds for machine tools, process machinery, test equipment, conveyors, and printing presses. It will operate continuously at full load in constant torque ranges as high 34:1. Bulletin 2750 provides details. 6 pages. Louis Allis Co., 427 E. Stewart St., Milwaukee 1, Wis. K

Circle 610 on Page 19

Locks & Mechanisms

Locks and locking mechanisms for practically every purpose are fully described in Catalog No. 105. Types covered include double-bitted types for drawers, doors, lockers, and cabinets; single-bitted locks for various purposes; seven-pin tumbler mechanisms; removable plug units; padlocks; and other types. 56 pages. Chicago Lock Co., 2024 N. Racine Ave., Chicago, Ill. J

Circle 611 on Page 19

Roller Chain Sprockets

Stock sizes of Acme Grip-Master sprockets and flexible couplings for roller chains as well as prices, dimensions, and engineering information are cited in Catalog 100B. Grip-Master plate and hub type mounts use tapered split bushing, keys, and set screws to facilitate shaft mounting and dismounting. 20 pages. Acme Chain Corp., Holyoke, Mass. B

Circle 612 on Page 19

Electric Controls

Pushbutton stations, speed-responsive switches, resistors, controllers, contactors, relays, drum controllers, and other electric control devices are briefly detailed in Bulletin 958. Guide to more extensive catalog sections is offered for each. 8 pages. Euclid Electric & Mfg. Co., Madison, Ohio. F

Circle 613 on Page 19

Models

Custombuilt product models for use in engineering design, laboratory test, technical sales, and engineering display purposes are illustrated in brochure. Services offered by company to produce scale models for any need are also covered. 6 pages. Industrial Models, Inc., 3000 Sconset Rd., Wilmington 3, Del. C

Circle 614 on Page 19

Air & Hydraulic Cylinders

Space-saving advantages of a line of 1⅛-in. bore, clamp-type cylinders with 1, 2, and 3-in. strokes are pointed out in Bulletin 159. Adaptable for front or rear flange, side, clevis, or pivot mounting, these CLH Series cylinders are usable on pressures to 1500 psi hydraulic and 250 psi air. 4 pages. Sheffer Corp., 326 W. Wyoming Ave., Cincinnati 15, Ohio. G

Circle 615 on Page 19

Finned Admiralty Tubing

A significant increase of 13 per cent in outside surface area has been incorporated in Trufin Admiralty Type S/T finned tubing for heat exchanger use. Catalog J7383 lists sizes, alloys, heat transfer data, and design information on many types of integrally finned tubing. 24 pages. Wolverine Tube Div., Calumet & Hecla, Inc., 17200 Southfield Rd., Allen Park, Mich. H

Circle 616 on Page 19

Circuit Breaker Control

The Telemand is a remotely actuated motor-operator which can open, close, or reset molded-case circuit breakers in ratings of 70 to 800 amperes. Design and performance characteristics of this unit are cited in Bulletin 5047-1A. 4 pages. I-T-E Circuit Breaker Co., 1900 Hamilton St., Philadelphia 30, Pa. C

Circle 617 on Page 19

PROTECTED BY Bonderite PARKER RUST PROOF CO. QUALITY CORROSION RESISTANT

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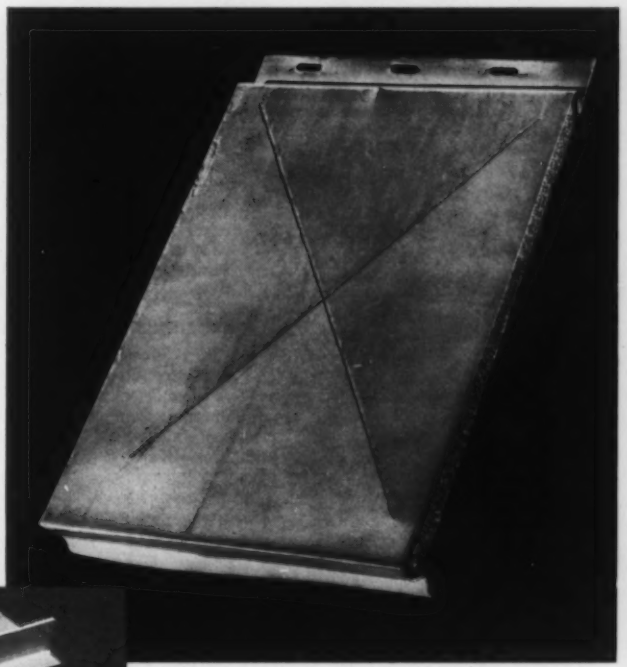

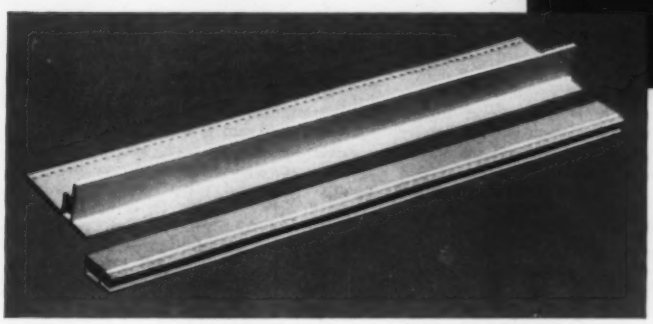

(Above): Regular 1-coat paint finish over section of Bonderite-treated aluminum siding. Formed after painting. Tested in salt spray 1500 hours. (Siding by Hastings Aluminum Products, Inc., Hastings, Mich.)

(Left): Aluminum window and screen frame sections Bonderized, painted in the strip, formed after painting. No breaks in finish anywhere! (Treated, painted strip furnished by Hastings Aluminum Products, Inc.)

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Circle 471 on Page 19

V-Belt Pulleys

Specifications of standard sizes of single-groove V-belt pulleys for fractional horsepower equipment are tabulated in illustrated circular. 4 pages. Nagel-Chase Mfg. Co., 2811 N. Ashland Ave., Chicago 13, Ill. I

Circle 618 on Page 19

Centrifugal Castings

"Nonferrous Centrifugal Casting Data" is title of Bulletin 157 which includes a detailed alloy chart showing comparative specs, chemical analyses, and minimum physical properties of Shenango nonferrous alloys. The broad range of component parts and assemblies which can be produced by the centrifugal casting method is shown. 8 pages. Shenango Furnace Co., Centrifugally Cast Products Div., Dover, Ohio. G

Circle 619 on Page 19

Custom Rubber Products

File form folder describes facilities of this company for the production of custommade rubber parts, seals, and components of natural, synthetic, and silicone compounds. Techniques used to make parts to close tolerances and for specific services are shown. 8 pages. Goshen Rubber Co., Goshen, Ind. J

Circle 620 on Page 19

Induction Motors

Form 943 is a tabulation of specifications, prices, and other information on squirrel-cage and wound-rotor induction motors, direct current motors, gearmotors, and other types in sizes ranging up to 400 hp. This condensed price list also covers controls. 6 pages. Century Electric Co., 1806 Pine St., St. Louis 3, Mo. I

Circle 621 on Page 19

Pumps & Blowers

Rotary positive pressure blowers, gas pumps, and vacuum pumps are subjects of illustrated bulletin S65C. Blowers range in capacity to 20,000 cfm at pressures to 10 psi. Gas pumps handle volumes to 10,500 cfm, while vacuum pumps deliver up to 20,000 cfm in range of 10-psi pressure to 20-in. Hg vacuum. Design and performance data are tabulated. 20 pages. Sutorbilt Corp., 2966 E. Victoria St., Compton, Calif. L

Circle 622 on Page 19

Force Measurement

Entitled "No. 1—Principles" is the first in a series of reference manuals to aid the engineer in understanding and updating force measurement through electronic systems. All phases of subject are shown and discussed. Load cells and their application are studied. 20 pages. Baldwin-Lima-Hamilton Corp., Electronics & Instrumentation Div., Waltham 54, Mass. B

Circle 623 on Page 19

Dial Thermometers

Complete facts about 1 to 4-in. dial thermometers in a full line of Fahrenheit and Centigrade ranges and constructions for any service are presented in Catalog DT2-58. Separable sockets are listed. 12 pages. Rochester Mfg. Co., 100 Rockwood St., Rochester 10, N. Y. N

Circle 624 on Page 19

Microwave Load Isolators

C-type magnets for microwave applications are designed for load isolation. These Alnico V permanent magnets in basic sizes and shapes are listed in Catalog 20. 2 pages. Indiana Steel Products Co., Valparaiso, Ind. J

Circle 625 on Page 19

DC Motor

Details and performance curve of the Model D-820 28-v dc motor which develops 0.8 to 3 hp are contained in Data Sheet G-182. Motor is designed for missile, aircraft, ordnance, marine, and industrial use. 2 pages. Hoover Electric Co., Hangar 2, Port Columbus Airport, Columbus 19, Ohio. G

Circle 626 on Page 19

Temperature Controls

How Thermoswitch units, which operate on the thermal differential expansion of metals, are used for nonindicating temperature control purposes are shown in Bulletin MC-177. They are offered for temperatures from −100° to 1500° F in various adjustable temperature ranges. Design and application guidance is offered. 8 pages. Fenwal Inc., Pleasant Street, Ashland, Mass. B

Circle 627 on Page 19

Potentiometers, Transducers

Key information on line of linear motion potentiometers, pressure transducers, accelerometers, and angular position transducers is summarized in brochure "Bourns Instruments." Range, resistance, resolution, linearity, hysteresis, power rating, and operating temperature specifications are given for individual models. 8 pages. Bourns Laboratories, Inc., Box 2112, Riverside, Calif. L

Circle 628 on Page 19

Ceramics

Mechanical and electrical properties of the most frequently used AlSiMag ceramics are tabulated in Chart 591. Twenty-six compositions are considered. Other data include thermal expansion, dielectric strength, and volume resistivity graphs. 8 pages. American Lava Corp., Chattanooga 5, Tenn. A

Circle 629 on Page 19

Time Delay Switch

Preliminary Bulletin 900 briefly describes the Series TH adjustable time delay switch. This thermally-actuated, snap-action device is available in several models with time cycles from 15 sec to 5 min. 2 pages. Industrial Timer Corp., 1407 McCarter Highway, Newark 4, N. J. D

Circle 630 on Page 19

Aircraft Valves & Filters

Valves, strainers, filters, accumulators, and other products for aircraft, missile, and industrial applications are catalogued in Condensed Facts Bulletin C-591. Selector index relates valve function and material to be handled to appropriate designs. Attention is given to valves for handling cryogenic mixtures. 12 pages. Koehler Aircraft Products Co., 409 Leo St., Dayton, Ohio. G

Circle 631 on Page 19

Adjustable Speed Drives

Industrial adjustable speed drive equipment described in Bulletin GB-3 are eddy current couplings, drives, brakes, and dynamometers, as well as magnetic clutches and brakes. Various models of Ajusto-Spede and Dynaspede drives, available in 3 to 75 hp ratings, are covered. 16 pages. Eaton Mfg. Co., Dynamatic Div., Kenosha, Wis. K

Circle 632 on Page 19

Terminal Pull Tester

Fast reliable testing of the mechanical strength of solderless electrical terminals can be done with the Hunter terminal pull tester reviewed in Bulletin 750e. Data sheet describes application, construction, and operation. 2 pages. Hunter Spring Co., 1 Spring Ave., Lansdale, Pa. E

Circle 633 on Page 19

Metalworking Machines

Catalog outlines automation equipment, components, and standard and special metalworking machines and pictures parts produced on these machines. A 6-page section is devoted to various models of standard machines and components. A full page chart shows drilling feeds, speeds, and horsepower requirements. 18 pages. Michigan Special Machine Co., 11449 Timken Ave., Warren, Mich. H

Circle 634 on Page 19

Steel Bearing Balls

Material, sizes, finish, grades, and tolerances relative to carburized, chrome, stainless, and alloy steel balls, as well as bronze balls are given in folder. Burnishing materials and imported chrome steel balls are also listed. 4 pages. Rayco Ball Co., 250 E. County Line Rd., Hatboro, Pa. E

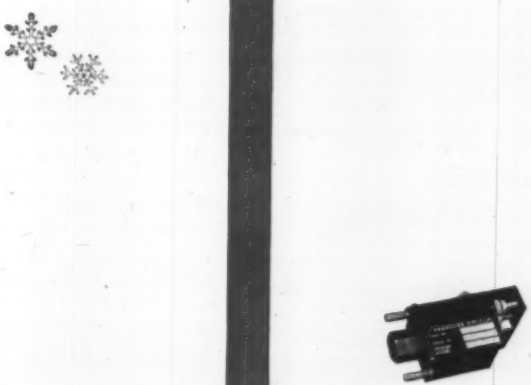
Circle 635 on Page 19

Explosive Ordnance

Specifications and performance data on a line of explosive ordnance products are contained in "Technical Data Book." Design guidance is offered on such items as explosive bolts, gas generators, pressure cartridges, igniters, squibs, initiators, destructors, and other explosive systems and devices. Request on company letterhead from McCormick Selph Associates, Hollister Airport, Hollister, Calif. M

Punching & Notching Units

Valid time studies of various fabrication operations using the Strippit system of punching, notching, nibbling, and drilling are included in illustrated general catalog. Tooling for press brakes and stamping presses shown includes Hydra-Springs, hole punching units, notching units, pierce nut units, and press accessories. Also shown are fabricating machines. 16 pages. Request on company letterhead from Wales-Strippit, Inc., 216 S. Buell Rd., Akron, N. Y. N



Wonders in Miniature. Snowflakes are excellent examples of how Nature uses tiny things to achieve great effects. Individually, these microscopic crystals are masterpieces of symmetrical beauty. Collectively, they have a decided influence on this planet's living conditions. Man follows Nature's lead by using miniaturization as a powerful force of action.

Miniature Pressure Switch, approximately 1¾″ long, has exceptionally high resistance to radiation. It maintains performance characteristics and calibration at 1000°F and in a reactor environment, operating in lines up to 10,000 PSI, with no seepage or leaks. Construction includes two MPB bearings to support movement of highly sensitive member.

Man With Miracles. Gordon Colson, an MPB Sales Engineer, worked closely with the firm producing the small high-pressure switch. He provided technical assistance for their engineers in selecting exactly the right bearings. To aid in solving your engineering problems with miracles in miniaturization, an experienced MPB technician is available.

New Miracles in Miniaturization

ACTUAL SIZE OF THE BEARINGS IN PRESSURE SWITCH SHOWN ABOVE

Reaching new heights, in outer space or in everyday industrial efficiency, calls for a good deal of new equipment, which usually calls for new miracles in miniaturization. And which, in turn, calls for experience like MPB's in making smaller bearings to meet greater scientific and industrial needs. MPB has specialized in this and produces over 500 types and sizes of bearings, ranging down to 1/10″ O.D., with specials as required. Our catalog will bring you complete facts on these. For catalog, or engineering advice, or both, **write Miniature Precision Bearings, Inc.,** 104 Precision Park, Keene, N. H.

MINIATURE PRECISION

MPB

BEARINGS, INC.

Helps you perform miracles in miniaturization

Circle 472 on Page 19

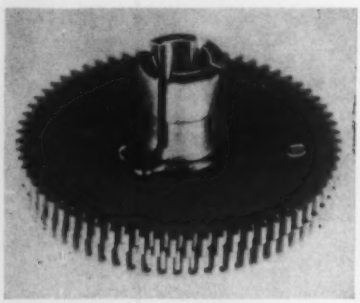
New Parts and Materials

Use Yellow Card, page 19, to obtain more information

Antibacklash Gears

miniature units are spring-loaded

For use in servo and instrument designs, miniature antibacklash gears have over-all length of only 5/16 in. in clamp-on type. Internal spring is used, and floating gear is prewound and restrained. Gear assembly is meshed by displacing floating portion one-half tooth. Standard gears are 96 pitch, size range is 66 to 110 teeth, and bores are 0.09, 0.12, and 0.125 in. Tolerances are in accordance with



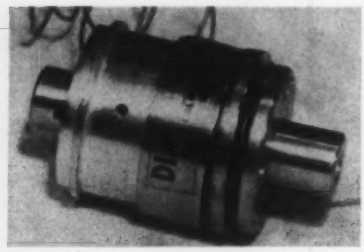
AGMA Precision 1 or better, and units meet requirements of MIL-E-5400. **Precision Mechanisms Corp.**, 577 Newbridge Ave., East Meadow, N. Y. D

Circle 636 on Page 19

Miniature Clutches

have no slip rings or brushes

Models SAC-100 and SAC-130 stationary-coil clutches can be supplied for various types of mountings such as bracket, shaft, and servo. Units are completely self-contained without slip rings or brushes. Features include zero backlash when energized, zero residual drag, and freedom from scoring due to engagement slip. All applicable military specifications are met for shock, vibration, temperature, and humidity.



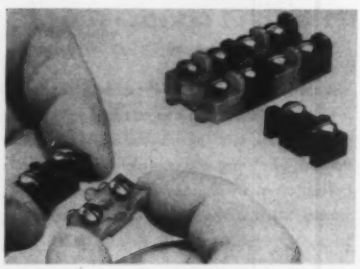
Size 100 has static torque of 15 oz-in. min., consumes 2 w power. Size 130 has static torque of 55 oz-in., and consumes 3½ w. **Dial Products Co.**, P. O. Box 456, Bayonne, N. J. D

Circle 637 on Page 19

Terminal Blocks

tiny units snap together to form rigid row

Semielastic Zytel terminal blocks are available in ten different colors for simple circuit coding. Series G blocks measure ⅜ in. wide, 13/32 in. high to top of barrier, ¼ in. high to top of block, and ¾ in. long. Rating is 20 amp at 110 v. Units snap together to form rigid rows which cannot separate after being fastened down. Insulating barriers are integral in each block. Full insulation protection is provided between blocks and fastening screws and panel, and between block pairs. Electrical connection between pairs is integral part of block. As many as 15 blocks can be snapped together and mounted with



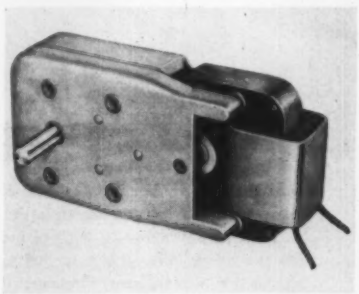
one screw at each end without risk of blocks coming apart. Snap-action assembly lugs and slots require no tools for assembly or disassembly. **Alpha Electric Products Co.**, 3625 N. Halsted St., Chicago 13, Ill. J

Circle 638 on Page 19

AC Motors

fractional-horsepower units have flat gear reducer

Thin-design, Z-type gear-reduction unit, only 1 13/32 in. thick, is incorporated in six SpeedWay subfractional-horsepower motors for appliance or general applications in limited-space, high-torque situations. Z-type unit features motor as an extension of gear case, with over-all length of 5½ in. and width of 2⅝ in. Unit has wide face gears to withstand high shock loads. It is



available in wide variation of load capacities with speed range as low as ¼ rpm, making it adaptable to many subfractional-motor applications. **SpeedWay Motor Div., Thor Power Tool Co.**, 1421 Barnsdale Rd., LaGrange Park, Ill. I

Circle 639 on Page 19

Retaining Ring

single-turn unit is for light-duty applications

Spirolox single-turn retaining ring is available in plain or stainless steel with cadmium, zinc, or Lubrite

finishes. It is designed for use on light-duty applications such as lens mountings, phonograph turntables, and other products where retaining rings are exposed to view. Diameters range from ½ to 5 in. Unit is easy to install or remove and is well suited to automation assemblies. **Ramsey Corp.**, 3693 Forest Park Blvd., St. Louis 8, Mo. I

Circle 640 on Page 19

Silicone Rubber

fibrous material has excellent mechanical strength

Mat of silicone-rubber fibers, oriented in a completely random manner, is a product with tensile and tear strength superior to silicone sponge and foam. Material, designated Cohrlastic FSR, has high permeability, good tear resistance, good tensile strength, density in the range of 20 lb per cu ft, good compression-deflection characteristics, and useable temperature range of −65 to +500 F. Material is available in sheets ¼ in. thick, 9 in. wide, and 6 ft long. **Connecticut Hard Rubber Co.**, 407 East St., New Haven 9, Conn. B

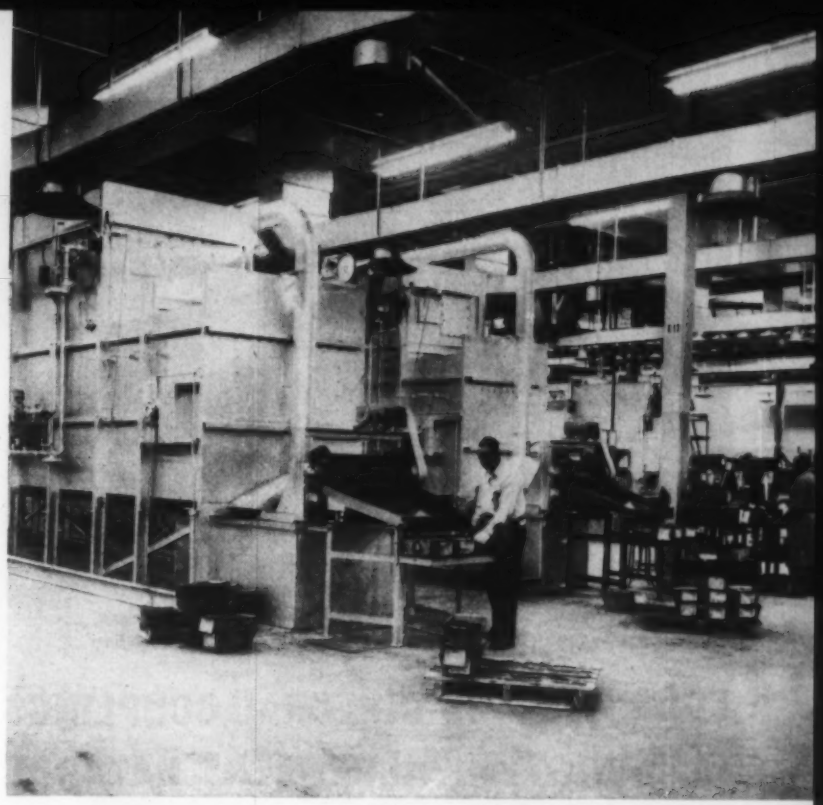
Circle 641 on Page 19

Iron Bearings

have high oil content and good wear resistance

Iron Oilite 212 bearings are available in sleeve, flange, or spherical types for use in a variety of applications where corrosion is not a problem. Bearings withstand continuous operation at moderately high speeds,

Circle 473 on Page 19→



New heat treating equipment produces better fasteners at

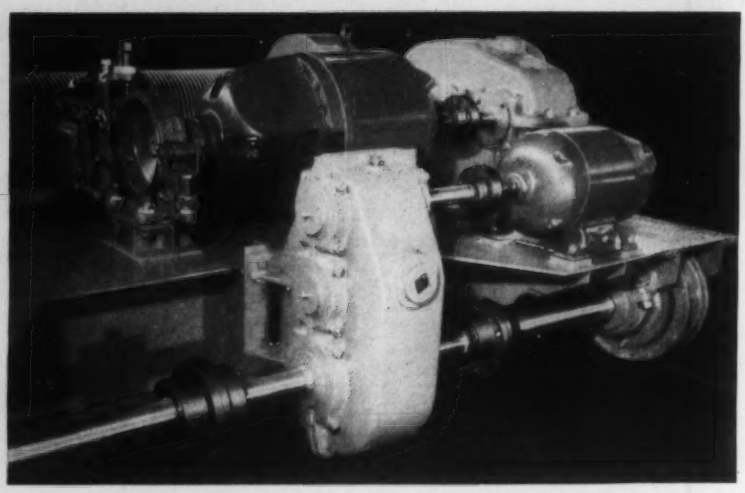
ALLEN

These new, specially designed Holcroft heat treating units harden, quench, wash, and temper in a continuous operation. Automatic devices regulate and record processing data for accurate, close control of this all-important manufacturing function.

Throughout Allen's great new plant, new facilities like these assure constantly higher quality in hex socket screws and related products. Today, more than ever, ALLEN is the "buy word" for socket screws, as well as keys, dowel pins, and pipe plugs.

Allen Flat Head Cap Screws, in countersunk tapped holes, give you absolutely flush surfaces. Where you can't countersink—fastening thin metal parts like covers, access panels, or guards, for example—Allen Button Head Cap Screws will give you the smooth, streamlined effect you want. Class 3A fit. Leader points, of course. Available from stock in all popular sizes. Ask your Industrial Distributor for samples and full information. Or write directly to The Allen Manufacturing Company, Hartford 1, Conn.

ALLEN HEAD HEX-SOCKET SCREWS

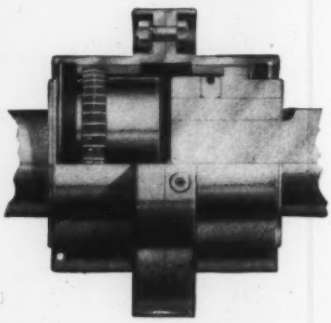


AJAX 3-D Dihedral Couplings with 3-degree capacity relieve strains between motors, gear boxes, and traction wheels.

FOUR AJAX 3D DIHEDRAL COUPLINGS ELIMINATE MISALIGNMENT HAZARDS ON CRANE AND HOIST TROLLEY

Crane service is hard service, Heavy loads, constant starting, reversing, and braking set up unavoidable weaving and twisting stresses on all components.

The photograph shows how AJAX 3-D Dihedral Couplings are incorporated in design to safeguard performance by protecting bearings, gears, armatures, frames, and housings against misalignment strains. Located between all driving and driven units of trolley and hoist, the four AJAX 3-D Dihedral Couplings insure against costly interruptions to crane service and difficult expensive repairs due to inaccessible overhead installations.



Cutaway section of AJAX 3-D Dihedral Coupling with 3-Degree angular and/or offset capacity. Other standard Dihedral Couplings up to 7 degree capacity.

Also AJAX Bronze bushed Rubber cushioned Couplings.

The patented Dihedral tooth design of AJAX Dihedral Couplings reduces backlash to the vanishing point, an important factor in the smooth operation and precise control essential to load handling.

The nationwide organization of AJAX Coupling specialists offers broad and fully qualified experience as an aid in improving performance and reducing costs.

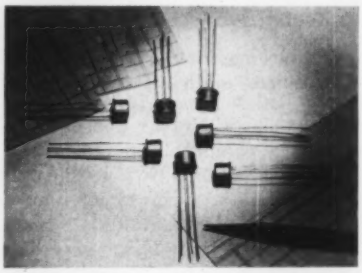
AJAX FLEXIBLE COUPLING CO. INC.
WESTFIELD, N. Y.
Representatives in Principal Cities

and give optimum performance when carrying medium to heavy loads at relatively low speeds. Wear resistance is excellent, and oil content is approximately 20 per cent by volume. Built-in service factor permits bearing to operate without oil for short periods. Applications include home appliances, fractional-horsepower motors, power tools, light machinery and vehicles, and communications equipment. **Amplex Div., Chrysler Corp.,** Detroit 31, Mich. H

Circle 642 on Page 19

Silicon Transistors

incorporate fixed-bed mounting technique



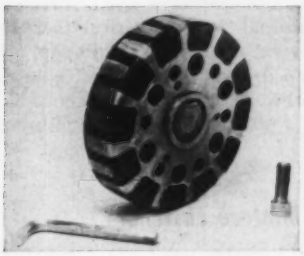
Line of 45-v silicon high-frequency transistors exceeds military reliability specifications for both mechanical and electrical characteristics. Fixed-bed mounting technique, using a ceramic disc, has been adapted to the line and produces low thermal resistance which permits lower junction temperatures at high dissipation levels. Seven units are designed for both amplifier and switching circuits and are JETEC type-designated 2N332 through 2N338. Lowest melting temperature in the transistors is 290 C. **Semiconductor Products Dept., General Electric Co.,** Syracuse, N. Y. C

Circle 643 on Page 19

Self-Aligning Coupling

flexible unit is spacer type

Flexible coupling has many applications in the marine and industrial fields, and fits shafts directly or can be adapted to existing flanges. Resilient synthetic rubber interlocking ring absorbs shock, gear, and other engine shaft vibrations, and allows



easy flexing movement between two sides of coupling. Unit has no moving parts and requires no maintenance or lubrication. Six sizes are available for flange diameters from 2⅞ to 7¼ in. and six shaft sizes from ¾ to 2 in. Maximum torque ranges from 1433 to 2293 lb-ft. Range of ODs is from 4 to 9⅝ in. **Voges Mfg. Co. Inc.**, 98th St. and 103rd Ave., Ozone Park 17, L. I., N. Y. D

Circle 644 on Page 19

Self-Cleaning Chain

has minimum of friction and heat

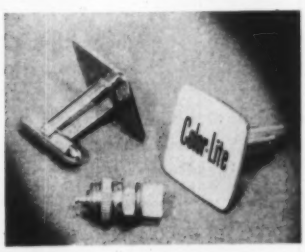
MSL chain has built-in lubrication between pin and bushing to reduce wear. Bushing extension acts as a lubricated thrust bearing so that chain runs free with minimum friction and heat. Unit is self-cleaning because of controlled clearance between pin-link plate and roller-link plate. **Whitney Chain Co.**, Hartford, Conn. B

Circle 645 on Page 19

Panel Indicator Light

has diameter of ¼ in.

Major applications of new indicator light for panels include missiles, missile test stands, aircraft, computers, and production equipment. Model T-1 Color-Lite is guaranteed for 100,000 hr at 5 v and 60,000 hr at 6.3 v. The ¼-in. diam unit is available in both single and two-



NOW!

Big switch features in small switch size

NEW DENISON LOXSWITCH MODEL M LIMIT SWITCH

Tested to over 45,000,000 cycles under electrical load

- Heavy duty nylon latch mechanism
- 3/8" wide contact gap
- Two completely isolated circuits, 1-NO, 1-NC
- 600 volt industrial control rating (not just pilot duty)
- Short trip differential—6°
- Fits thousands of existing layouts
- Plug-in convenience—or direct wiring
- 50° safety overtravel—both directions
- Light actuating force—45 oz./in.
- Water-, oil-, dust-tight—NEMA 12

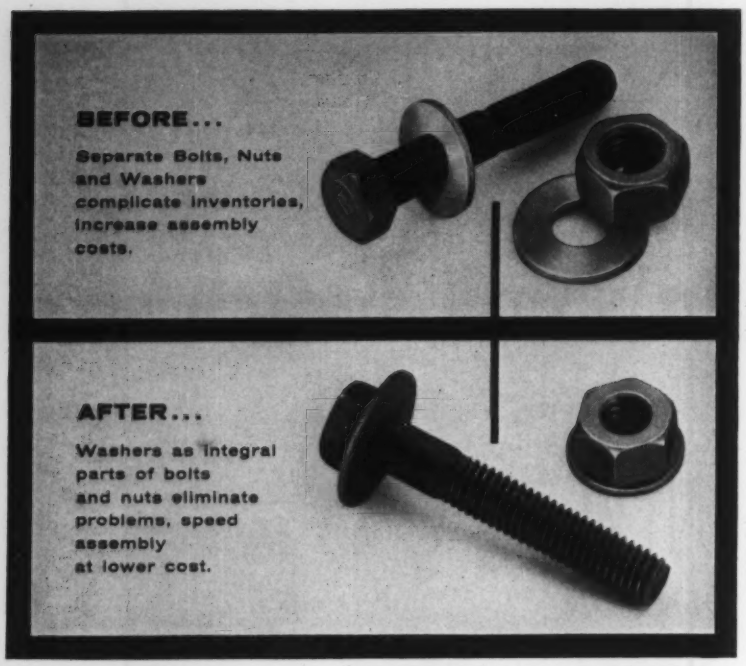
FREE—4-page folder gives complete dimensions, specifications, prices, lever styles, boxes. Write for Bulletin M-1, R. B. Denison Mfg. Company, 102 St. Clair Avenue, N.W., Cleveland 13, Ohio.

DENISON

LOXSWITCH

Wire with LOXSWITCH and you wire for good!

Circle 475 on Page 19


BEFORE...
Separate Bolts, Nuts and Washers complicate inventories, increase assembly costs.
AFTER...
Washers as integral parts of bolts and nuts eliminate problems, speed assembly at lower cost.

Save Money

by simplifying fastener design

Here is a simple application of a basic bolt making principle which is affecting substantial savings for a number of manufacturers.

These savings, resulting from simplified design, are realized in every step of the operation from lower first cost of the fasteners through inventory to final assembly. Totalled, they are well worth while.

There are many other basic principles . . . often overlooked in designing and specifying fasteners, which are of importance cost-wise.

You'll find them in our new booklet, "How to specify fasteners . . . and save". Filled with drawings and charts, it makes a handy guide in designing or buying any headed parts.

If you can use a copy, write to North Tonawanda or ask a Field Representative.

BUFFALO BOLT COMPANY

Division of Buffalo-Eclipse Corporation

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MAKING BOTH FASTENERS AND FRIENDS FOR 100 YEARS

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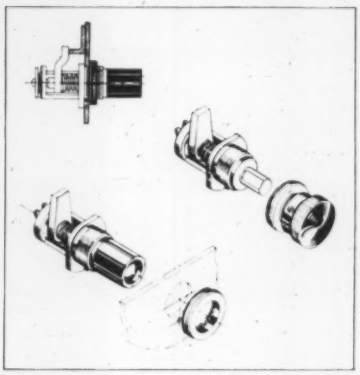
terminal models with either fixed or removable bulbs. Light cap, available in red, white, green, blue, and amber, is only $\frac{1}{8}$ in. in diam. **Sloan Co.**, 4029 Burbank Blvd., Burbank, Calif. L

Circle 646 on Page 19

Miniature Fastener

adjustable pawl eliminates rivets and bolts

No. 48 adjustable pawl fastener is supplied in three types for frame thickness: Up to $\frac{1}{4}$ in., $\frac{1}{4}$ to $\frac{1}{2}$ in., and $\frac{1}{2}$ to $\frac{3}{4}$ in. It eliminates rivets or bolts usually required to hold fastener body to door or panel. One



9/16-in. diam hole takes fastener shaft, and another 0.082-in. diam hole receives a stop pin on fastener to prevent it from rotating. Unit automatically adjusts pawl position to accommodate variations in frame thickness up to $\frac{1}{4}$ in. Continued rotation of plastic and steel knob increases applied pressure. Two knob styles are available, or fastener is supplied with flatted shaft so that any knob with $\frac{1}{4}$-in. hole can be used. **Southco Div., South Chester Corp.**, Lester, Pa. E

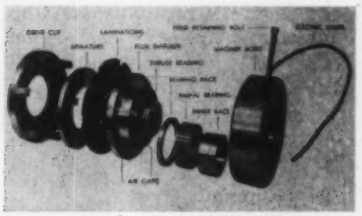
Circle 647 on Page 19

Magnetic Clutch

uses stationary magnetic field

Design of EC-S magnetic clutch for use in machine transmissions incorporates a closed flux path through hardened steel laminations, eliminating need for adjusting air gaps. Use of a stationary magnetic field, with coil windings on stator instead of rotor, eliminates slip rings and brushes. Five sizes are available

Circle 476 on Page 19



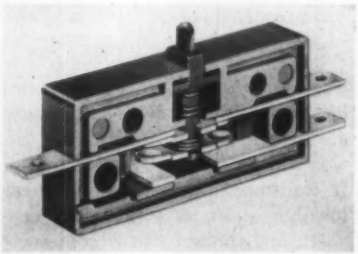
with torque ratings ranging from 14 through 290 lb-ft. Long, cone-shaped air gap is oriented approximately 30 deg relative to shaft axis. Thrust load on roller thrust bearing is reduced by converting a portion of it to bear against radial needle bearing. Flux density across gap is reduced with enlarged air gap cross-sectional area. Clutches are available for standard 24 or 90-v dc operation, with other voltages available on special order. **I-T-E Circuit Breaker Co.**, 1900 Hamilton St., Philadelphia 30, Pa. C

Circle 648 on Page 19

Momentary-Contact Switch

30-amp unit has simplified action

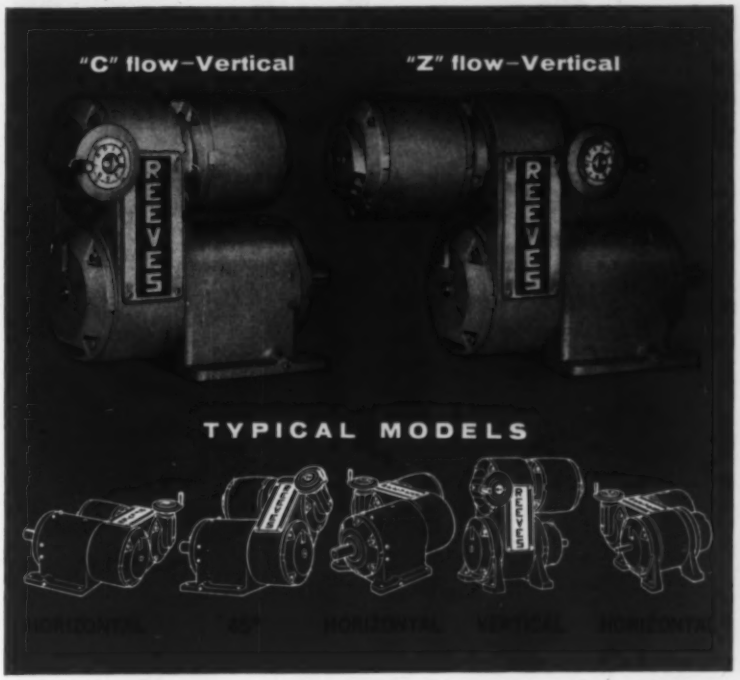
Momentary-contact switch provides long life and high electrical capacity for its size in a low cost, easy-to-apply unit. Switching action is simplified to include two precision - wound, stainless - steel springs. One spring returns stem to normal position and the other maintains constant, evenly distributed pressure on contacts. Vibration is absorbed to eliminate bouncing of contact bridges and premature switch failure. Switches, designated Series 1901, can be used singly or can be stacked in any combination to provide multiple-pole units. All models are available with pin plunger, pushbutton, leaf, and leaf with roller actuation. Electrical ratings are: 30 amp, 125 or 250 v ac, non-inductive; 25 amp, 125 or 250 v



NEW **REEVES**®

*Sizes 200-300-400 Vari-Speed MOTODRIVES**

* *200-300-400 Sizes, 1 through 10 hp.; full line, ¼ through 40 hp.*



The flexible design of these compact new REEVES variable speed power packages permits hundreds of combinations . . . space-saving, space-fitting *standard* assemblies to meet most installation requirements. All models are available in both "C" flow and "Z" flow styles.

New increased capacity is built in the reducers—single, double or triple stages...new disc assemblies permit wider output speed ranges . . . discs are pre-aligned . . . pre-loaded spring maintains correct belt tension for longer belt wear . . . *exclusive* "close-grooving" lubrication assures free sliding discs . . . new Metermatic system automatically lubricates the motor and variable shaft bearings.

Complete information on all phases of the versatile 200-300-400 sizes Vari-Speed Motodrives is given in new Catalog. Write for your free copy today—Dept. H32f-M571.

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REEVES PULLEY COMPANY

Division of **RELIANCE** ELECTRIC AND ENGINEERING CO.

Columbus, Indiana

Circle 477 on Page 19

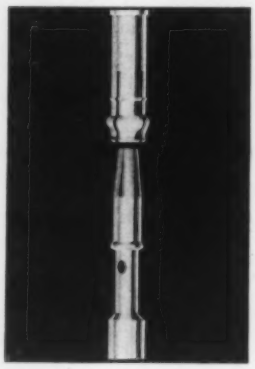
ac, inductive, 1 hp, 125 v ac; 2 hp, 250 v ac; 2 amp, 125 v dc; ½ amp, 250 v dc. **Electrical Div., McGill Mfg. Co. Inc.**, Valparaiso, Ind. J

Circle 649 on Page 19

Connector Contacts

miniature units have metallic sleeve

Re-entrancy miniature contacts can be removed or replaced easily with pliers or by hand, eliminating need for special tools. They employ metallic sleeves with long cantilever springs to ensure ease of insertion and withdrawal. Design permits interchangeability of male and female contacts at all times. Additional features of the contacts, designated Remi, include: Mechanical



stresses confined between metallic elements rather than between plastic and metallic elements; use of dummy pins which permits additional polarization and keying; and removal of contact from wiring side without disengaging connector. Units withstand severe environmental conditions and are designed to meet all types of crimp-on requirements. **U. S. Components Inc.**, 454 E. 148th St., New York 55, N. Y. D

Circle 650 on Page 19

Shaft Collar

transmits thrust and torque loads

Torque or thrust collar is spring locked to a shaft with grip equivalent to a shrink fit, and will not work loose under severe vibration. It transmits torque loads up to allowable stress of cold-rolled steel shaft, and thrust loads which exceed

Design Uniform lift into equipment with DUFF-NORTON WORM GEAR JACKS

Many designers find a ready answer to precise control of linear motion in machinery or equipment with built-in Duff-Norton Worm Gear Jacks.

They are used singly, in tandem and in multiple jacking arrangements to position loads weighing from a few hundred pounds to as much as several hundred tons.

When connected in tandem or groups of four, six or more, these jacks always raise or lower in exact unison regardless of load distribution. They are also used for application of pressure, to push or pull and as linear actuators.

Duff-Norton Worm Gear Jacks are self-locking and will hold heavy loads in position indefinitely without any creep. Since there is no fluid or air to leak, the action is always positive and maintenance is no problem.

These jacks are available in eight standard models with capacities ranging from 2 to 100 tons and with standard raises from 6 to 24 inches. Special raises can also be furnished.

To learn more about how Duff-Norton Worm Gear Jacks may be used in your equipment, send for the bulletin which shows engineering drawings of jacks, Duff-Norton Mitre Gear Boxes and typical applications. Ask for AD-66v.

DUFF-NORTON COMPANY

P. O. Box 1889 • Pittsburgh 30, Pennsylvania

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DUFF-NORTON JACKS
Ratchet • Screw
Hydraulic • Worm Gear

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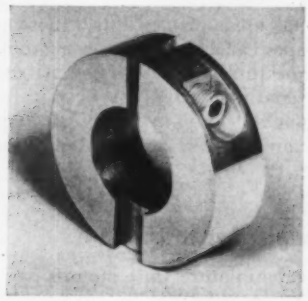
Ratchet Lever • Air
Hand Chain • Electric

Circle 478 on Page 19



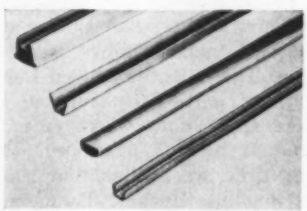
rating of some types of roller thrust bearings, without use of conventional shaft keys, splines, shoulders, and snap rings. Only assembly tool needed is an Allen wrench. Sizes are available to fit cold-rolled steel shafts from 3/4 to 2 in. Torque collar (shown) is positively locked both axially and radially to machine elements such as pulleys, gears, sprockets, and cams when assembled on a shaft, even though they are easily separated when removed from shaft. Thrust type does not have dovetail slot across face. **Kolock Products Co.**, 127 Ridgefield Rd., Lutherville, Md. C

Circle 651 on Page 19

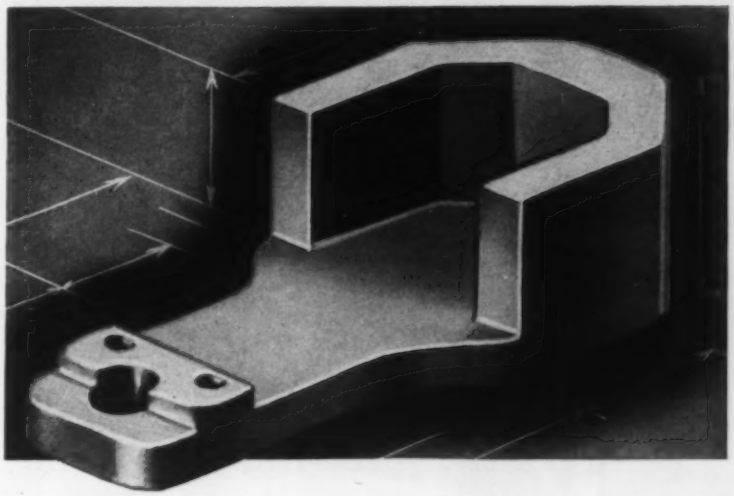
Profile Extrusions

of filled nylon provide low surface friction

Continuously extruded profile shapes of Nylatron GS, a molybdenum disulphide-filled nylon, are used for runners, conveyor or channel tracks, sash linings, and general sliding contact or protective wear surfaces in the machinery, automotive, aviation, or architectural fields. Profiles reduce wear and friction on sliding surfaces. Nylon does not gall or erode metals or other materials in absence of lubrication, and smooth, noisefree action is easily obtained. Material provides low surface friction and imparts increased rigidity and dimensional stability to the extrusions. Custom shapes are available with total cross-sec-



economy...speed... in volume production of complex parts...



The photograph shows a bearing support plate for a new line of power tools manufactured and marketed by a large and very capable organization.

The complex nature of the part is apparent at a glance and the cost of machining such a part is evident to the eye of engineer and designer.

It is on parts of this nature that powder metallurgy offers its greatest advantages and its greatest opportunities for the future.

Such parts require most careful designing of the tooling from which they are produced, plus painstaking and tedious effort until the part can finally be produced in volume.

A manufacturer with such requirements naturally turns to Bunting where the necessary persistence until success is achieved is one of the Company's recognized characteristics.

For the unusual, as well as the usual, in bearings, bushings, bars and special parts of cast bronze or sintered metals, see Bunting first.

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Bunting's "Engineering Handbook on Powder Metallurgy" and Catalog No. 58 listing 2227 sizes of completely finished cast bronze and sintered oil-filled bronze bearings available from stock.

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Toledo 1, Ohio EVergreen 2-3451

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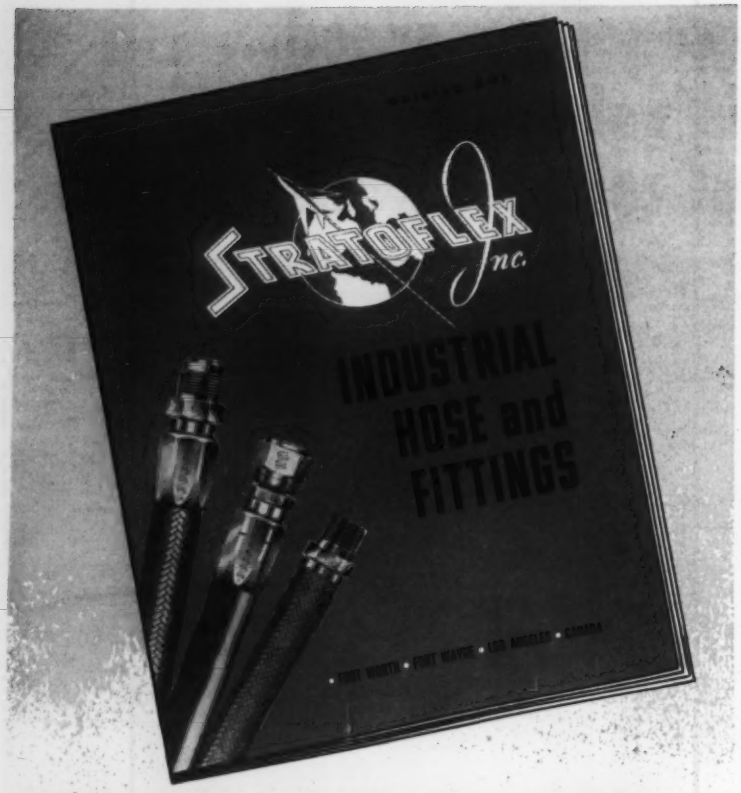
Circle 479 on Page 19



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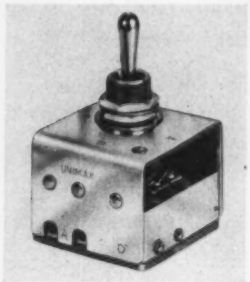
tional areas of 0.003 to 0.15 sq in. Shapes can be force-fit in or around connecting members. They are used in continuous lengths or cut into segments. **Polymer Corp. of Pennsylvania**, 2140 Fairmont Ave., Reading, Pa. C

Circle 652 on Page 19

Toggle Switch

subminiature unit mounts in less than 2⅜ in. square

Type 8SB2-1 switch combines advantages of multicircuit control, single-hole panel mounting, and toggle actuator, with subminiature size. Unit mounts in less than 2⅜ in. square. Assembly consists of eight Type USM5 switches, secured in a mounting bracket, with four-way toggle mechanism. The 15/32-in. threaded bushing permits single-



hole mounting in panels up to ¼ in. thick. Toggle is maintained in center position and is spring returned from each of four possible operate positions. Electrical ratings of each basic switch are: 2.5 amp, 30 v dc, inductive; 5 amp, 30 v dc, resistive; 5 amp, 125/250 v ac. **Unimax Switch Div., W. L. Maxson Corp.**, Ives Road, Wallingford, Conn. B

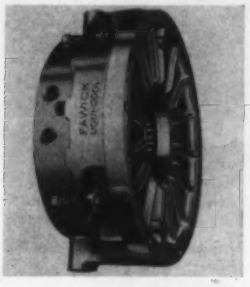
Circle 653 on Page 19

Clutches and Brakes

have high heat dissipation rates

Disc-type clutches and brakes with water-coded copper pressure plates provide heat dissipation rates up to ten times greater than similar water-cooled units using cast-iron plates. The units, designated Liquicool, are particularly suitable for severe applications where excessive frictional heat is developed. Five basic sizes are available in single and dual-disc designs. Torque rat-

Circle 480 on Page 19



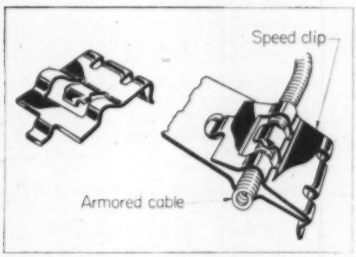
ings for single-disc units range from 4500 to 100,000 lb-in. Dual-disc models have ratings from 9000 to 200,000 lb-in. with same diameter and mounting dimensions. Disc sizes range from 7¾ to 24 in. Internal gear drive has straight-through bore for use on ¾ to 10-in. diam shafts. **Airflex Div., Fawick Corp.**, 9919 Clinton Rd., Cleveland 11, Ohio. F

Circle 654 on Page 19

One-Piece Cable Clip

provides positive, vibrationproof fastening

New Speed Clip secures small-diameter armored control cables on electrical equipment, automobiles, and other products. Replacing embossed stampings, screws, rivets, and other auxiliary fastening devices, clip offers positive, vibrationproof fastening at any location along cable and provides unlimited re-use without damage to cable or clip. **Tinnerman Products Inc.**, P.O. Box 6688, Cleveland, Ohio. F

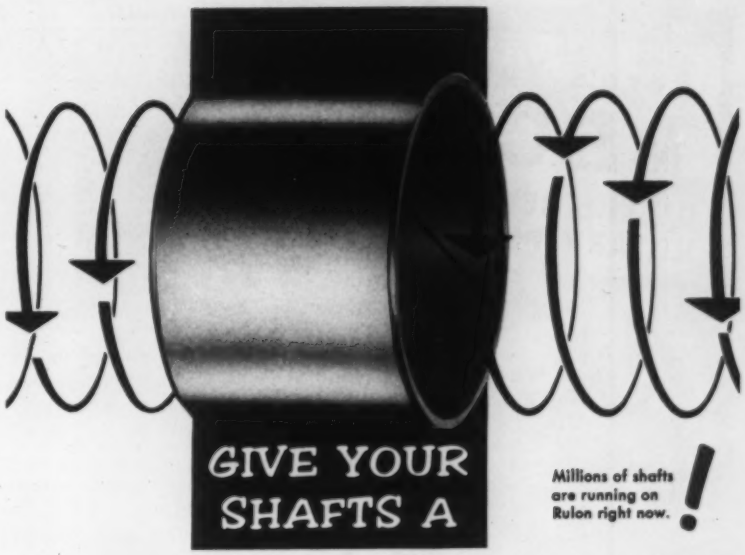


Circle 655 on Page 19

Solenoid Valve

handles noncorrosive liquids and gases

Two-way direct-lift solenoid valve has only one moving part. It handles steam, air, gas, light oil, water, and other noncorrosive liquids and



FREE RIDE

on this low cost antifriction bearing

Dixon's T-Liner Sleeve Bearings . . . with antifriction "floating" Rulon® insert (modified TFE Teflon†). . . are ready-built for installation in your designs. Available off the shelf in ten standard sizes, T-Liners give free riding, low friction performance on rotary or linear moving shafts.

These new bearings are recommended for PV values up to 10,000 *without lubrication!* (PV is the product of load on bearing in psi times rubbing speed in feet per min.) A thin Rulon insert within the metal shell . . . having extremely low coefficient of friction and 12 times the wear resistance of nylon . . . automatically adjusts itself to compensate for temperature changes. Unlike most plastics, Rulon is unaffected by moisture. Frictional heat is quickly dissipated through the liner and shell. Because of compactness and wide temperature adaptability (from sub-zero to 500°F), T-Liners answer many difficult space and environmental design conditions.

Besides eliminating lubrication, these bearings overcome problems of dirt, noise, and corrosion. They're lightweight, easy to install, and virtually maintenance-proof.

If your product incorporates rotating, reciprocating, or oscillating shafts, it will pay you to investigate Dixon T-Liners.

Engineering Data Sheet 32-T gives complete details. Write for your copy today.

DIXON CORPORATION
Bristol, Rhode Island

Standard Rulon T-Liner Bearings			
No.	**ID in.**	**OD in.**	**Length in.**
5201	¼	11/32	⅜
5202	5/16	⅜	⅜
5203	⅜	½	½
5204	½	⅝	½
5205	⅝	¾	¾
5206	¾	⅞	¾
5207	⅞	1	¾
5208	1	1⅛	1
5209	1⅛	1¼	1
5210	1¼	1⅜	1

†Du Pont TM

Dixon

suppliers of basic shapes and fabricated parts in Rulon and Teflon.

Circle 481 on Page 19

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ABC's
ON THE NEWEST
ROTARY PUMPS

A SERIES
LOW TO MEDIUM VISCOSITY

High speed units to pump 3 to 25 gpm . . . low speed units 20 to 97 gpm. Maximum operating pressures to 100 psi. Gear, V-Belt or direct drives.

B SERIES
HAZARDOUS LIQUIDS

Sealed units U. L. Approved. High speed pump up to 23½ gpm . . . low speed pump to 90 gpm. Maximum U.L. pressure rating for hazardous fluids 50 psi. Gear, V-Belt or direct drives.

C SERIES
RUGGED DUTY
MEDIUM-HIGH VISCOSITY

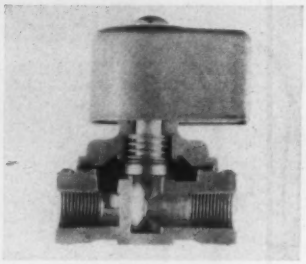
Continuous operation. Packed pumps. Heavy outboard thrust bearing. Pump up to 211 gpm at pressures to 125 psi. and direct drives. V-Belt and Gear. Threaded or flanged ports. Also Series "E" steamjacketed pumps.

D SERIES
RUGGED DUTY
MECHANICALLY SEALED

For broad group of liquids of wide viscosity range. Pump up to 211 gpm @ 450 RPM. May be operated at pressures to 100 psi. Gear or gear-motor drives. Threaded or flanged ports.

Wayne
PUMPS
THE WAYNE PUMP COMPANY
Industrial Division
FORT WAYNE 4, Indiana
Division of Symington Wayne Corporation

Circle 482 on Page 19



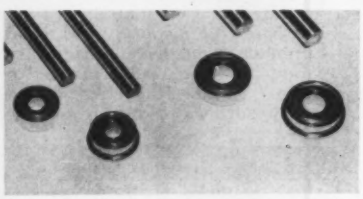
gases. Depending upon medium controlled, valve is suitable for general-purpose applications having main-line pressure up to 40 psi. Mountable in any position, valve can be used for industrial heating control applications, sanitary installations, and vacuum service. It has forged-brass body and bonnet, stainless-steel core and spring, and Buna-N disc. Valve is available with 5/16-in. orfice in either $\frac{3}{8}$ or $\frac{1}{2}$-in. NPT connections. **Automatic Switch Co.**, Florham Park, N. J. D

Circle 656 on Page 19

Ball Bearings

have better than ABEC 7 tolerance

Type E precision ball bearings have bore tolerances of +0.0000, −0.0001, better than ABEC 7 tolerance. Units permit better fit in



all precise instrument assembly applications. **PIC Design Corp.**, 477 Atlantic Ave., East Rockaway, L. I., N. Y. D

Circle 657 on Page 19

Message Display Unit

displays 20 messages on common 3 x 5 screen

Lenticular multimessage display stores 20 messages on a common viewing screen. Any one message can be selected and displayed by lighting one of a matrix of 20 miniature incandescent bulbs. Distortionfree messages are assured since no lens-projection system is em-

ACCEPT
NO
SUBSTITUTE

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The American Laundry Machinery Co., Rochester, N. Y.
Atlas Foundry Co., Detroit, Mich.
Banner Iron Works, St. Louis, Mo.
Barnett Foundry & Machine Co., Irvington, N. J.
Blackmer Pump Co., Grand Rapids, Mich.
E. W. Bliss Co., Canton and Toledo, Ohio and Hastings, Mich.
Centrifugally Cast Products Div., The Shenango Furnace Co., Dover, Ohio
Compton Foundry, Compton, Calif.
Continental Gin Co., Birmingham, Ala.
The Cooper-Bessemer Corp., Mt. Vernon, Ohio and Grove City, Pa.
Crawford & Doherty Foundry Co., Portland, Ore.
Dayton Casting Co., Dayton, Ohio
Empire Pattern & Foundry Co., Tulsa, Okla. and Bonham, Texas
Florence Pipe Foundry & Machine Co., Florence, N. J.
Fulton Foundry & Machines Co., Inc., Cleveland, Ohio
General Foundry & Mfg. Co., Flint, Mich.
Georgia Iron Works, Augusta, Ga.
Greenlee Foundries, Inc., Chicago, Ill.
The Hamilton Foundry & Machine Co., Hamilton, Ohio
Hardinge Company, Inc., New York, N. Y.
Hardinge Manufacturing Co., York, Pa.
Johnstone Foundries, Inc., Grove City, Pa.
Kanawha Manufacturing Co., Charleston, W. Va.
Kennedy Van Saun Mfg. & Eng. Corp., Danville, Pa.
Koehring Co., Milwaukee, Wis.
Lincoln Foundry Corp., Los Angeles, Calif.
Nordberg Manufacturing Co., Milwaukee, Wis. and St. Louis, Mo.
Palmyra Foundry Co., Inc., Palmyra, N. J.
The Henry Perkins Co., Bridgewater, Mass.
Pohlman Foundry Co., Inc., Buffalo, N. Y.
Rosedale Foundry & Machine Co., Pittsburgh, Pa.
Ross-Meehan Foundries, Chattanooga, Tenn.
Sonith Foundries of FMC, Indianapolis, Ind.
Standard Foundry Co., Worcester, Mass.
The Stearns-Roger Mfg. Co., Denver, Colo.
Vulcan Foundry Co., Oakland, Calif.
Washington Iron Works, Seattle, Wash.
Dorr-Oliver-Long, Ltd., Orillia, Ontario
Hartley Foundry Div., London Concrete Machinery Co., Ltd., Brantford, Ontario
Otis Elevator Co., Ltd., Hamilton, Ontario

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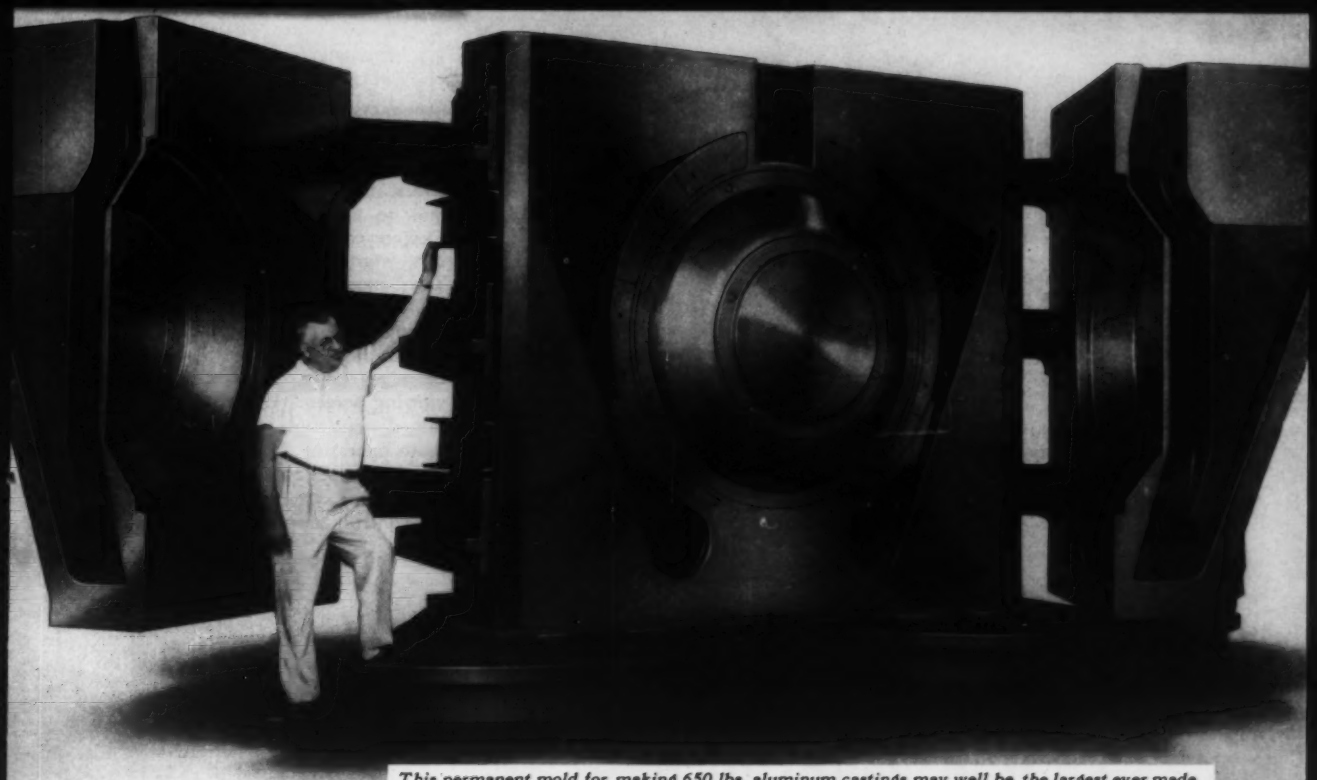
SINGLE COPY

Bulletin 23 — "Meehanite® — The Metal For Permanent Molds."

Write today to Meehanite Metal Corporation, Department 4D, 714 North Avenue, New Rochelle, New York.

MEEHANITE®



This permanent mold for making 650 lbs. aluminum castings may well be the largest ever made. Cast in type GA, Meehanite metal by Fulton Foundry & Machine Co., Inc. of Cleveland, Ohio, it weighs 25-tons assembled.

Meehanite permanent molds offer resistance to heat checking and distortion from thermal shock.

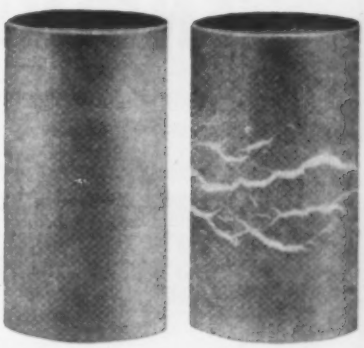
Premature cracking or disintegration of surface is a serious problem to the users of permanent molds. Severe service conditions demand the selection of a metal with a dense close-grained structure which maintains dimensional accuracy and resists the disastrous effects of thermal shock.

Meehanite metal has the ability to more than meet these requirements and is used extensively for permanent molds in the production of both ferrous and non ferrous castings, glass, plastics and other materials. The huge mold illustrated is proof of the confidence placed in Meehanite.®

The chief advantage of a Meehanite mold is consistent uniformity of structure throughout the casting. Meehanite's dense, stabilized structure resists thermal shock, insures freedom from distortion and dimensional changes. Easily machined, it provides the smooth, highly polished surface so essential to good finish and long production life.

Meehanite molds can be cast closely to shape to reduce machining operations. Also, they may be heat treated or flame hardened where high hardness is required.

Write for free literature: Bulletin 23 — "Meehanite® — The Metal For Permanent Molds."



The block on the right reveals what happens when an ordinary permanent mold material is suddenly heated and cooled. The Meehanite block on the left, given same test, shows complete freedom from surface cracking.

MEEHANITE BRIDGES THE GAP BETWEEN CAST IRON AND STEEL®

MEEHANITE METAL

MEEHANITE METAL CORPORATION, NEW ROCHELLE, NEW YORK

Circle 483 on Page 19

The Design Equation that Saves You Money...

Use easy-to-install, economical National Retaining Rings to locate and position bearings or parts on pins, shafts and in housings. Eliminate grinding or machining shaft stock to form shoulders. You save time and material and reduce weight and space requirements. Ask for data on your specific application, today!

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= improved design + economy!

ALL TYPES AND FINISHES AVAILABLE—National rings are supplied in square, round and rectangular types of carbon spring steel, bronze, beryllium-copper, stainless steel and aluminum in a wide selection of finishes. Send drawings or sample part for recommendations.

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Circle 484 on Page 19

HUMAN-FACTORS ENGINEERING

by John D. Vandenberg and C. Thomas Goldsmith

Thirty-one pages of helpful information for the designer contending with human limitations and capabilities. Special emphasis is given to design for vision, hearing, muscular performance and body dimensions in relationship to man-machine efficiency. **$1.00 per copy**

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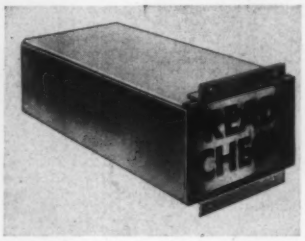
ployed. There is no interference between messages, and switching from one to another is instantaneous. Devices can also present digits, letters, words, charts, or photographs. Two models are available: Type LD-22 displays 16 messages on a common 2¼ x 2¼-in. viewing screen; Type LD-35 displays 20 messages on a common 3 x 5-in. viewing screen. Units are self-contained, and are designed for remote operating from any switching system. Applications include missile-control systems, industrial process control, annunciators, computer



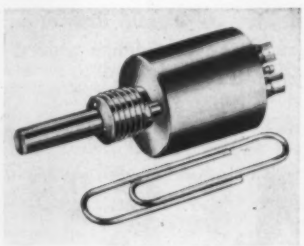
console displays, test equipment, radar, and nuclear instrumentation. **Electronic Tube Div., Burroughs Corp.**, P. O. Box 1226, Plainfield, N. J. D

Circle 658 on Page 19

Miniature Potentiometer

has one-piece metal case and bearing design

Miniature precision potentiometer, a ½-in. unit, incorporates one-piece metal case and bearing design which eliminates need for special assembly precautions. Components are completely enclosed by molded covers with integrally cored, solid terminals that cannot loosen or transmit solder, resin, or other foreign matter into unit. Completely sealed covers and O-ring-sealed shafts are available for maximum resistance to corrosive environmental conditions. Unit has multi-finger, precious-metal contact brush.



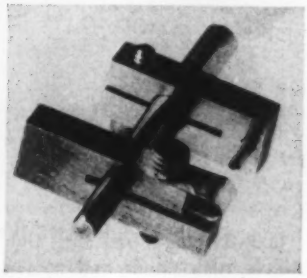
Threaded bushing, servo, ball bearing, and other shaft arrangements are available. Maximum torque is 1 oz-in. per unit. Potentiometer, designated C-050, dissipates 1.5 w with maximum temperature rise of 60 C. **Electronic Sales Div., DeJur Amsco Corp.**, 45-01 Northern Blvd., Long Island City 1, N. Y. D

Circle 659 on Page 19

Zero-Backlash Coupling

has clearance diameter of 1⅛ in. maximum

Zero-backlash instrument coupling is used to couple two shafts of same or differing diameters of 0.09, 0.093, 0.12, 0.125, 0.156, 0.187, 0.241, 0.25, and 0.313-in. sizes. It has maximum clearance diameter of 1⅛ in. and measures 7/16 in. axially.



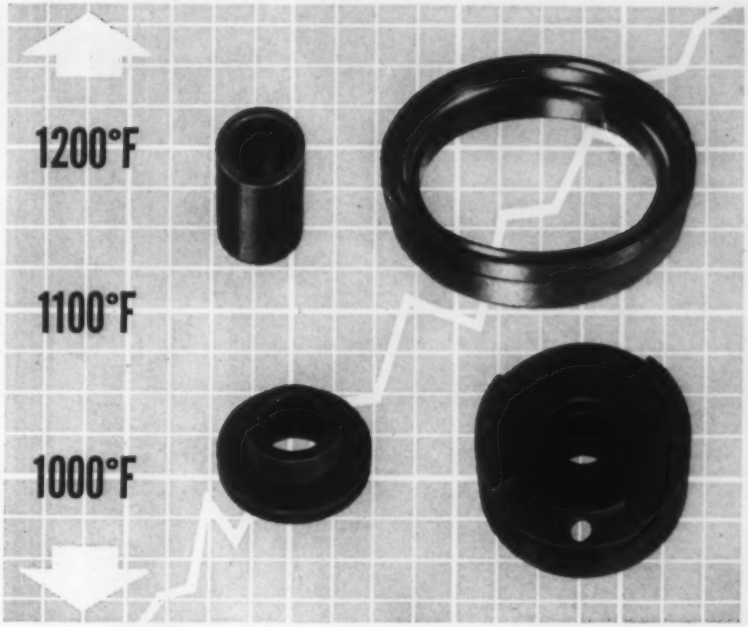
In addition to coupling function, unit can serve as a clamp for split-hub gears. **Gap Instrument Corp.**, 116 E. Merrick Rd., Freeport, L. I., N. Y. D

Circle 660 on Page 19

Glass Cloth

is impregnated with Teflon resin

Dilecto GB-108TED laminated plastic features lower permeability and higher dielectric strength than materials formerly available. It consists of glass cloth impregnated with Teflon resin. Material is designed for corrosive applications such as gaskets and seals, and for flexible electrical insulation such as radar windows, printed circuits, and tape cable. Material combines high tensile strength and resistance to flow of glass-cloth laminates with low permeability, excellent chemical resistance, and superior electrical properties of Teflon. It is also flexible, has high tear resistance, and can be



A NOTABLE NEW HIGH-TEMPERATURE GRAPHITE

for mechanical uses

When mechanical applications call for a material having low friction and low wear rates at temperatures where ordinary graphite and even many metals fail, Stackpole Grade 469 high-temperature graphite may well be the answer. Typical applications include extensive use as main bearing oil seals on turbo-prop engines and as bearing inserts in turbine blade pitch adjusting mechanisms.

A special treatment that inhibits oxidation assures maximum performance between 1000° and 1200° F. and will not "bleed out." The material is also good at lower temperatures.

Grade 469 is self-lubricating, will not seize or fuse and is unaffected by most chemicals and gases. Transverse strength is better than average. It is supplied in blanks or finished pieces or as bearings press-fitted into stainless steel housings.

Hundreds of other low-cost Stackpole carbon and graphite materials are likewise available. Send details of your application for suitable grade recommendation.

STACKPOLE CARBON CO., St. Marys, Pa.

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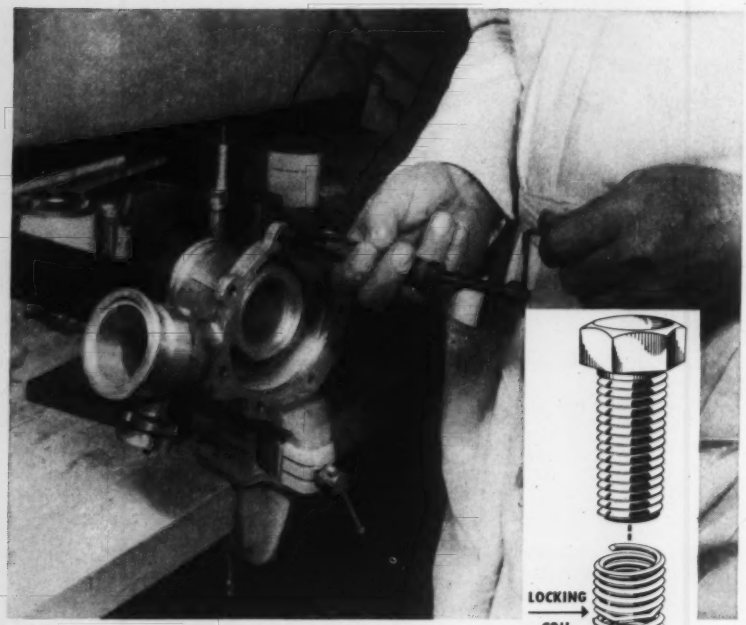
BRUSHES for all rotating electrical equipment • COMPOSITION ELECTRICAL CONTACTS • BEARINGS • SEAL RINGS • VOLTAGE REGULATOR DISCS MOLDS & DIES • FRICTION SEGMENTS • CORROSION CONTROL RODS HEATING ELEMENTS • CHEMICAL ANODES • BRAZING BOATS • WELDING CARBONS . . . and many other carbon, graphite and metal powder products.

Circle 485 on Page 19



Heli-Coil® Stainless Steel Screw-Lock Insert is easily wound into tapped hole in lightweight aluminum housing. Spring tension of the locking coil retains screw securely, meets military specifications for locking torque and vibration.

How Carrier Corporation

Saves 40% in weight • 30% in assembly time

...with *HELI-COIL*® SCREW-LOCK INSERTS*

Use of aluminum lightens Carrier refrigeration system in Douglas DC-8 Jetliner

To reduce weight in the refrigeration system designed for air conditioning the giant Douglas DC-8 Jetliner, Carrier engineers used aluminum alloy compressor castings. To obtain maximum performance and reliability of threaded connections exposed to heat and vibration encountered at 600 mph, they selected the *Heli-Coil* stainless steel wire thread, *internal locking* Screw-LOCK Insert.

The results: design simplified, boss areas minimized, weight reduced as much as 40%, lock nuts and lock wiring eliminated. Now one man assembles the entire unit in 30% less time than before ... and danger of thread failure and screw loosening has ended!

Manufacturers in every field are relying on one-piece, stainless steel *Heli-Coil* Screw-LOCK Inserts to meet torque and vibration specs... protect threads against wear, stripping, galling and corrosion... save costs, space and weight. *Patented

HELI-COIL CORPORATION
DANBURY, CONNECTICUT

HELI-COIL CORPORATION, 504 Shelter Rock Lane, Danbury, Connecticut
I'd like more information on *Heli-Coil* Screw-LOCK Inserts
NAME_____ TITLE_____
FIRM_____
ADDRESS_____
CITY_____ ZONE____ STATE_____ 1508

IN CANADA: W. R. WATKINS CO., Ltd., 41 Kipling Ave., S., Toronto 18, Ont.

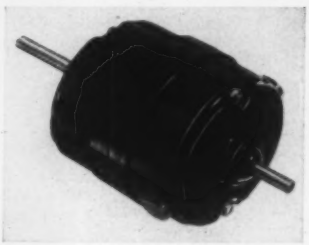
formed into simple shapes. Material is available as continuous, natural-color, smooth-finish sheet in coils, in 0.009-in. standard thickness. Thicknesses of 0.008 and 0.007 in. are also furnished. Maximum width available is 6 in., and maximum length is 75 ft. **Continental-Diamond Fibre Corp.**, Newark, Del. C

Circle 661 on Page 19

Fractional-Horsepower Motor

in voltages from 6 to 220

Motor with die-cast frame has an efficient ventilating system which occupies a minimum of space. Fractional-horsepower unit, called M-60, is available in any voltage from 6 to 220. It can incorporate reversing and dynamic braking, and is available with either ball or sleeve bearings. Tolerances can be held very close. **Rae Motor Corp.**, 2005 Kewaunee St., Racine, Wis. K



Circle 662 on Page 19

Metal-to-Metal Seal

withstands temperatures from −20 to +650 F

New metal-to-metal seal is based on the principle of two metal surfaces coming into contact on a single line plane. Members are designed so that small pressures establish complete seal between seat and poppet. Rubber or other synthetic seal aids are not needed, and seal is not affected by extreme changes in temperature. Unit, designed for applications that involve critical and varying degrees of pressure, flow, and temperature, is applicable to all types of valves. It withstands temperatures from −20 to +650 F. **Hydraulic Mechanisms Inc.**, Dept. PEN, 1047 61st St., Brooklyn 19, N. Y. D

Circle 663 on Page 19

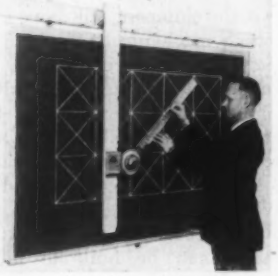
ENGINEERING DEPARTMENT

EQUIPMENT

Drafting Machine

for chalkboard use in demonstrations, conferences

Tracmaster drafting machine accurately measures and plots lines, angles, and curves directly on chalkboard for demonstrations and conferences. Unit glides smoothly across board, horizontally and vertically, with excellent balance and accuracy of angle and dimension. Protractor and scale rotate freely, locking in position at any drawing angle. Unit is especially valuable for rapid locating and positioning of x-y co-ordinates, establishing reference points, measuring and drawing long lines, without cumulative errors and extra work of repeated scale extension. Numbered grid graduations are engine-divided every 10 in. along both horizontal and vertical beams. Protractor provides full 360-deg visibility of all angles,



automatic 15-deg indexing stops, ball-bearing indexing head, and powerful baseline setting. Unit installs directly to wall above chalkboard with two mounting brackets. **Universal Drafting Machine Corp.**, 7960 Lorain Ave., Cleveland 2, Ohio. G

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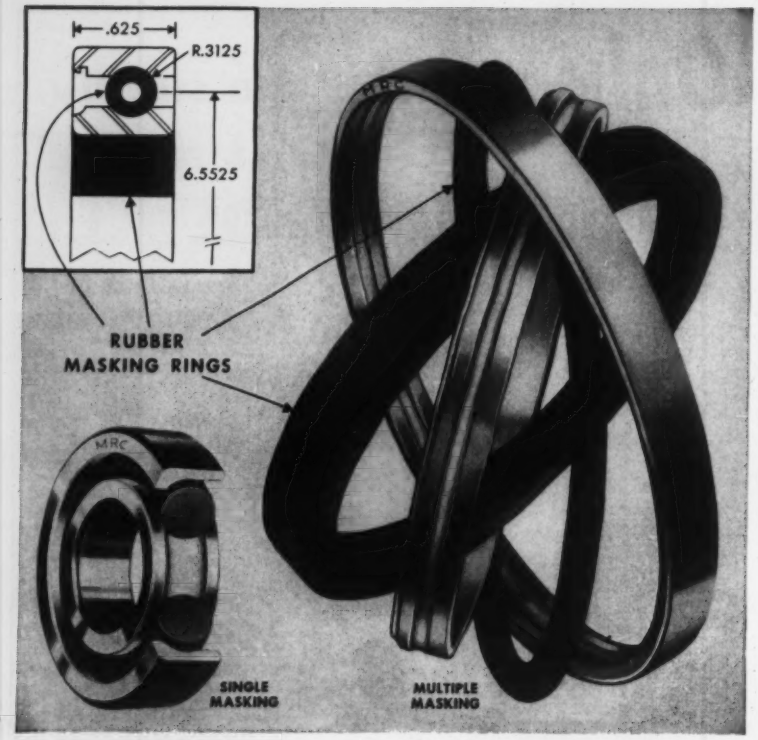

Photos courtesy Marlin-Rockwell Corp., Jamestown, N. Y.

Rubber Rings Mask Bearings during Plating Process

Here's a new way to mask out plating on bearing race grooves without tedious hand-labor. Regardless of bearing size, rubber rings are fitted precisely into ball grooves and inner ring bore so that plating can't sneak under the rubber even in torturous electroplating baths. Clean division lines always result. Inner ring and outer ring are held together so both can be plated simultaneously. This saves one complete plating cycle. And, this fast assembly prepares bearings for plating in seconds—eliminates costly hand-painting with unreliable stop-off lacquer.

These rubber rings are the result of Marlin-Rockwell Corporation (Jamestown, New York) consulting Continental to solve an important masking problem. Creative engineering successfully developed these extruded and spliced, or molded rubber rings which increased production 2000%—20 times faster than hand-painting. What's more, the special rubber compound withstands repeated baths in blistering acids and caustics without affecting precise dimensions, elasticity or resilience.

This rubber ring technique is typical of the thinking and ingenuity behind rubber parts by Continental. It also represents the economy and better end results accomplished by consulting a rubber specialist *during the planning stage* of a product. If you need help like this, call or write Continental—rubber specialists since 1903.

Engineering catalog.

In addition to custom-made parts, Continental offers an extensive line of standard grommets, bushings, bumpers, rings and extruded shapes. Hundreds of these are shown in the No. 100 Engineering Catalog. Send for a copy or refer to it in Sweet's Catalog for Product Designers.

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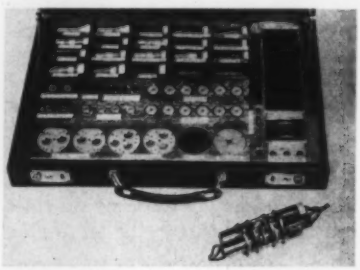
pencils have opaque leads available in 18 degrees, graded to permit constant uniform density. They withstand extreme pressure, are smooth, noncrumbling, and sharpen to a fine, clean point. Degree of hardness is marked on three sides for easy identification. Star pencils are furnished in ten degrees of hardness, marked on two sides for quick identification. Chrome colored pencils can be sharpened to blunt or fine points and are excellent for drawing, sketching, marking, and checking. Twelve nonsmear colors are available. **Alvin & Co. Inc.**, 853 Palisado Ave., Windsor, Conn. B

Circle 665 on Page 19

Servomechanism Kit

for construction of
$1\frac{7}{8}$-in. diam mechanisms



Servo development kit No. 1 contains all mechanical parts and tools necessary to construct $1\frac{7}{8}$-in. diam mechanisms to the complexity of computer component shown. Completed mechanisms can be sealed into standard 2-in diam enclosures for airborne applications and prototype evaluation. Indicators, control elements, and computer components can be built to military specifications. **Servo Development Corp.**, 567 Main St., Westbury, N. Y. D

Circle 666 on Page 19

Microfilm Printer-Reader

makes large prints
in 15 sec

Thermo-Fax Twenty-Nine microfilm reader-printer automatically makes prints up to 18 x 24 in. of engineering drawings and other detailed documents from microfilm. Unit is both a reader and printer in a single unit, producing prints in less than 15 sec by pushbutton.

Circle 488 on Page 19

Unit accommodates 35mm microfilm in aperture cards or tabulating card sizes. Operation is achieved by anyone without previous experience or training. Sharp, permanent copies are produced for immediate use and any number of copies can be made. Masking control permits selective printing of full or half-size prints. Table-top unit is 32 in. high, 31 in. wide, 36 in. deep, and operates on regular room current. Lens provides magnification of 15X and covers standard D-size aperture. **Minnesota Mining & Mfg. Co.**, Dept. S9-129, 900 Bush Ave., St. Paul 6, Minn. J

Circle 667 on Page 19

Photo-Recording Paper

for use in oscillographs

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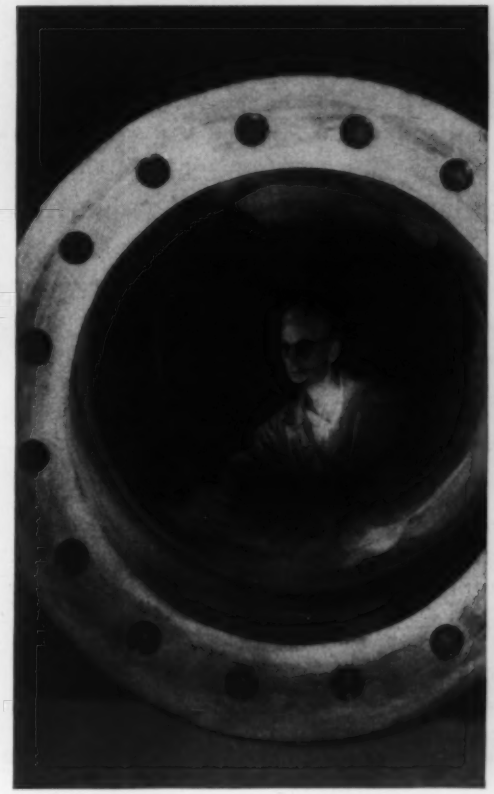
Circle 668 on Page 19



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Electrical Measurements. *By Arthur Whitmore Smith, late professor of physics, and M. L. Wiedenbeck, professor of physics, University of Michigan; 307 pages, 6 by 9 in., clothbound; published by McGraw-Hill Book Co. Inc., 330 West 42nd St., New York 36, N. Y.; available from* MACHINE DESIGN, *$7.50 per copy postpaid.*

Basic electricity and magnetism are treated theoretically and experimentally. Original chapters review electrostatics; discuss ammeters, voltmeters, and galvanometers; and demonstrate measurement of resistance, power, inductance, and capacitance.

Major changes in this fifth edition are: A new chapter on error treatment, substitution of mathematics for graphical methods, application of dc-circuit theorems to ac circuits, use of complex notation for circuit theorems and their use in unbalanced bridges, discussion of vacuum-tube circuit equivalents, and introduction of solid-state electronics with several transistor experiments.

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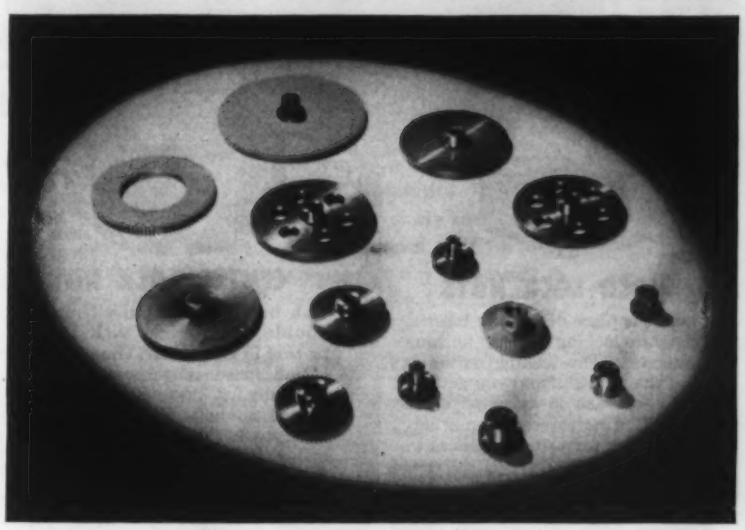

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sign, Case Institute of Technology; 418 *pages,* 6 *by* 9 *in., clothbound; published by John Wiley & Sons Inc.,* 440 *Fourth Ave., New York* 16, *N. Y.; available from* MACHINE DESIGN, $9.50 *per copy postpaid.*

The author presents industrial case studies as design projects which create need for a theory, have a variety of solutions, and can be reused regularly.

General topics include limit dimensioning, materials to match job requirements, and repeated stress effects since this information is not usually presented in fundamental texts. Machine elements included in the projects are bearings, belts, gears, brakes, columns, springs, rubber bushings, shafts, wire rope, keys, splines, and pins.

Manufacturers' Publications

Shot Peening. 193 *pages,* 6 *by* 9 *in., clothbound; published by and available from Wheelabrator Corp.,* 451 *S. Byrkit St., Mishawaka, Ind.;* $2.50 *per copy.*

Benefits of shot peening, what it is, and how it is done are explained in this sixth edition. Described are effects on fatigue resistance, stress-corrosion cracking, and lubrication properties. Merits of airless and air-blast peening are presented. Included are three papers on theory of prestressed surfaces in relation to shot peening.

Government Publications

OTS Technical Reports. *Copies are available from Office of Technical Services, U. S. Dept. of Commerce, Washington* 25, *D. C.*

The following reports are available:

PB 151235. Metallurgical Investigation of Aluminum Alloy X2219-T6. By Paul L. Hendricks, WADC; 22 pages, 8½ by 10¾ in., paperbound, stapled; $0.75 per copy.

Alloy contains copper, manganese, vanadium, and zirconium; available in sheets, plates, extrusions, and forgings; determination of design properties included tensile, fatigue, stress rupture, and stress corrosion characteristics at temperatures up to 600 F.

PB 151264. Oxidation of Experimental Alloys. By Joseph C. Richmond and H. Richard Thornton, for WADC; 49 pages, 8¼ by 10¾ in., paperbound, stapled; $1.50 per copy.

Ten alloys tested were aluminum-modified Nichrome V, Nichrome V, niobium-modified Nichrome V, iron-chromium-aluminum, Inconel 702, Hastelloy R235, Hastelloy W, type 316 stainless steel, Inconel X, and Inconel; average depth of external oxide and maximum depth of oxide penetration were measured for 100 hr under five stress and four temperature levels in air and for 100 hr under stress with temperature cycling above 1200 F; weight gain was continuously recorded for 100 hr air oxidation at four temperatures.

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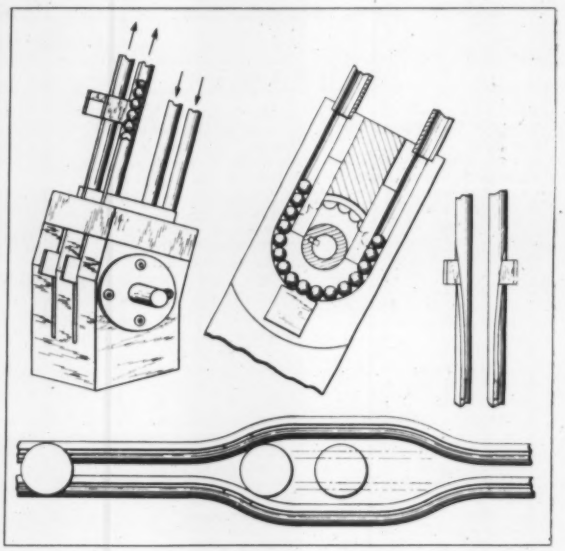
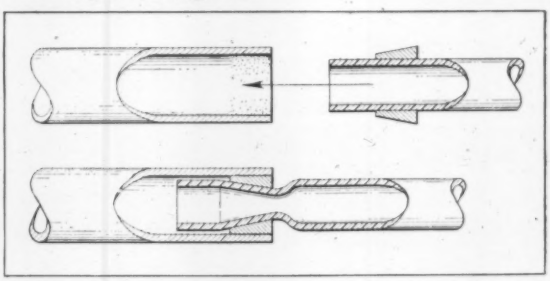
Balls, forced through slotted tubes, are the conveying medium in a versatile materials handling system. The balls are circulated by a powered sprocket. At ad-



justable intervals, certain balls carry extensions which project through the tube slot and contact the materials being processed. Tubes can be used in pairs, like tracks. In that case, methods of unloading include sprung tubes and twisted tubes. *Patent* 2,877,886 *assigned to Thompson Products, Cleveland, by Murray D. Braid.*

Fluid-Tight Tubing Joint

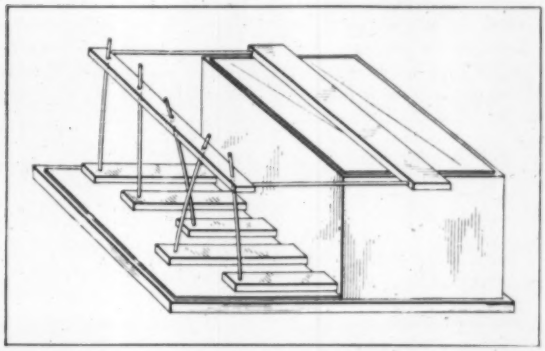


The assembly of a nonrigid tube inside a rigid tube is made fluid-tight by a flexible collar on the nonrigid tube. To grip the collar, a length of the ID of the rigid tube is roughened. The outer shape of the collar is a frustrum of a cone. The collar functions like a common bottle cork. *Patent* 2,874,981 *assigned to*

Cutter Laboratories, Berkeley, Calif., by Sherwood Joshua Brady.

Deflected-Spring Line Plotter

A straight line, forming the graphic average of a number of plotted points, is positioned automatically by simultaneous deflections of a like number of cantilever

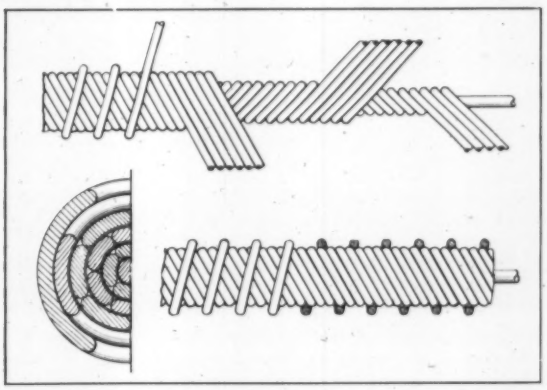


springs. The fixed ends of the springs are held in bars moved to positions corresponding to x or y co-ordinate values. Free ends of the springs are passed through holes in a straight-edge which floats to a position where spring deflections, hence x or y co-ordinates, are averaged. *Patent* 2,877,950 *assigned to Western Electric Co., New York, by John A. Olsen.*

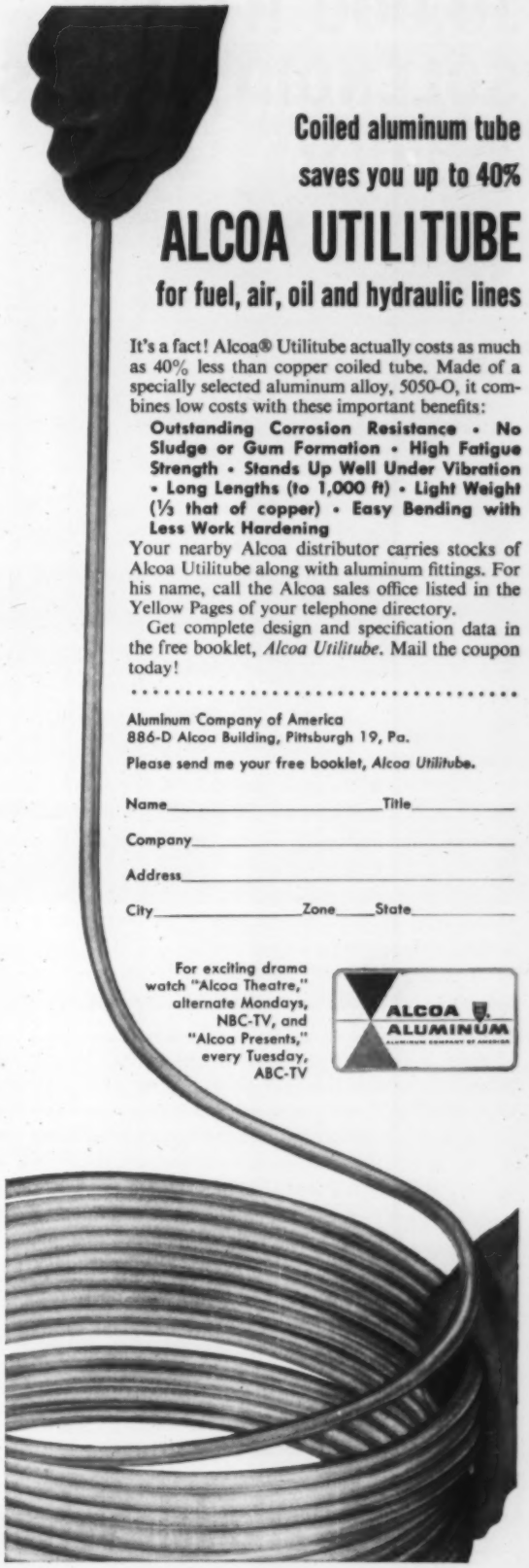
Gas Buffer

In an explosive-driven mechanism, the hot gas of combustion which moves a piston is also bled around the piston, through cylinder-wall grooves. The action cushions the piston at the end of its stroke. *Patent* 2,877,750 *assigned to Olin Mathieson Chemical Corp. by Karl W. Maier.*

Flexible Power Screw



Flexible cable, composed of multiple, closed-helix strands wrapped on a straight wire core, transmits thrust in either axial direction and torque in either circumferential direction. Layers of wire are wrapped



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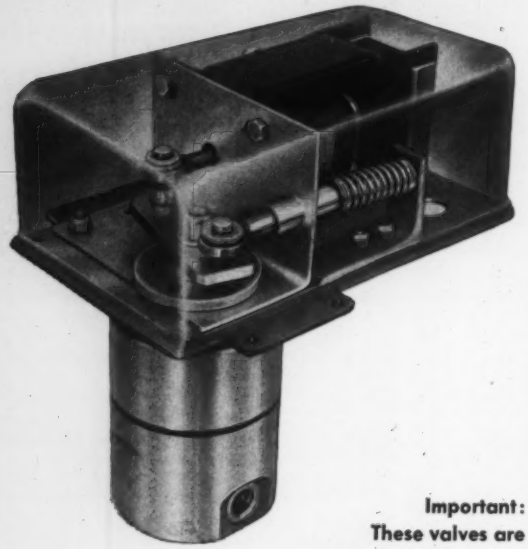
ALCOA ALUMINUM

Circle 496 on Page 19

10,000 P.S.I. SOLENOID VALVES



Important: These valves are standard catalog items.

● They are available for immediate delivery (in stock) at standard valve prices, for a service which generally requires costly (made-to-order) special valves.

● Shut off and 4-way valves in ¼, ⅜ and ½ inch port sizes are rated for 10,000 P.S.I. liquid or gases. They will withstand surges of up to 15,000 P.S.I. without damage to the valves' sealing qualities (designed for a burst pressure of 30,000 P.S.I.).
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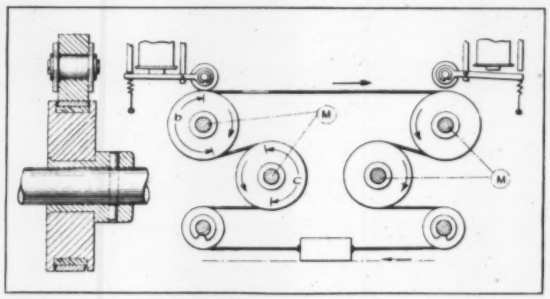
For complete data write for catalog S-10000.

CONTROL VALVE DIVISION
barksdale valves
5125 ALCOA AVENUE • LOS ANGELES 58 • CALIFORNIA

alternately clockwise and counterclockwise. Atop this basic cable, a single strand forms an open helix which functions as a worm thread and drives a carriage along the cable. *Patent* 2,875,597 *assigned to Teleflex Inc., North Wales, Pa., by Frank A. Neubauer.*

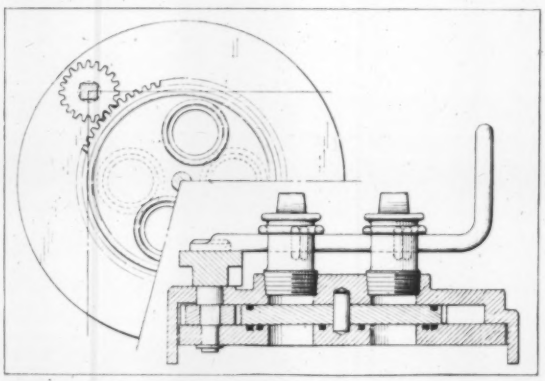
Two-Direction Tape Drive

Rapid linear movement between definite limits is provided by an endless tape driven by motor-powered capstans—a separate pair for each direction. Regardless of tape movement, each capstan rotates continually



in only one direction. On its circumference, each capstan carries a loose-fitted ring of friction material under the tape. The tape is moved in one direction when an idler, actuated by an electromagnet, loads the tape against a friction ring and its capstan. In the same way, an opposing idler reverses tape travel. Wrapping action of the tape on driving capstans minimizes input actuating power. *Patent* 2,878,684 *assigned to Burroughs Corp., Detroit, by Franklin W. Kerfoot.*

Geared Closure



After threaded plugs are backed out of holes in the cap of a closure assembly, rotation of a crank through 90 deg clears access to the interior of a tank or vessel. A pinion on the crank axis engages teeth on the rim of a sealing plate. A quarter turn of the crank rotates the plate enough to align plate holes with corresponding holes in stationary members. *Patent* 2,878,829 *assigned to Union Tank Car Co., Chicago, by Clyde H. Folmsbee.*

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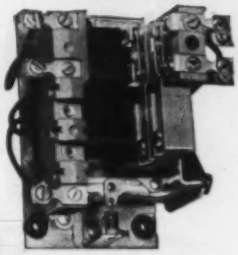

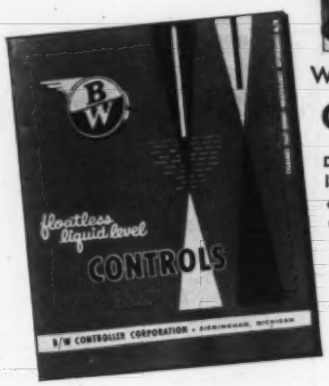

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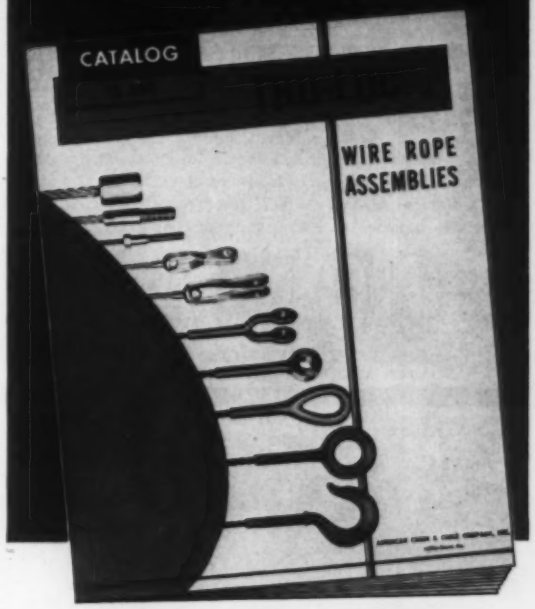

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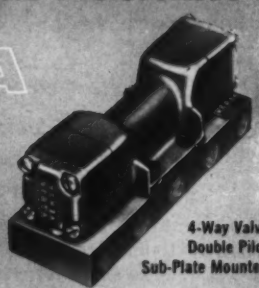

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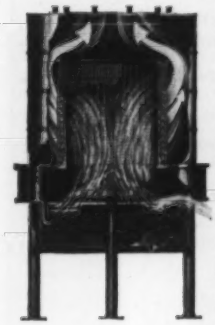

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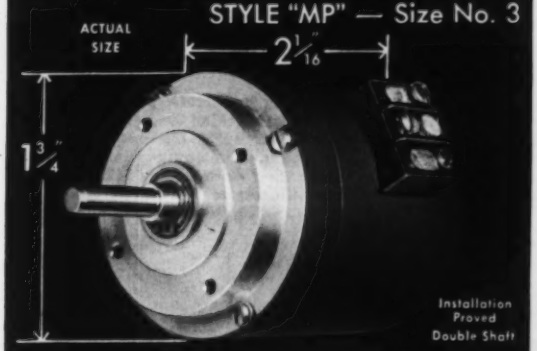

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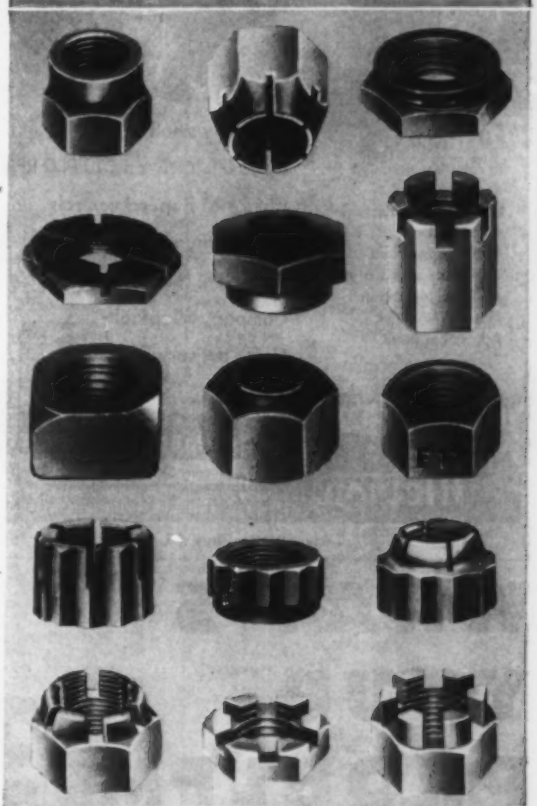

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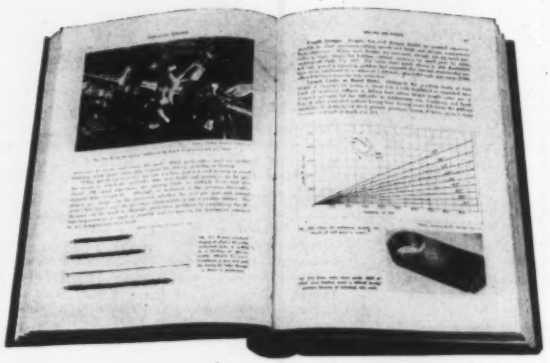

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The three "gang members" are Junior Red Cross members who've taken an afternoon of their time to go to the hospital and entertain some little crippled kids. Reassuring, isn't it?

They do things like this all the time. Regularly. Girls and boys.

20 million of our sons and daughters make up Junior Red Cross—the largest youth organization in the country. Junior members take part in every one of the Red Cross service programs that young people can help to carry on.

When disasters hit, Junior Red Cross volunteers help in many ways—as messengers, typists, canteen workers, information clerks. Many Junior Red Cross members have served with real distinction in disaster emergencies.

Through the Gift Box Program in their schools, Juniors send relief supplies to children overseas. Like all Junior Red Cross activities, this program is financed entirely by the Juniors themselves.

Friendship between children all over the world is fostered by the Junior Red Cross correspondence-album and art programs.

Junior Red Cross is at work every day, helping to build a strong, decent, responsible young America.

These are kids we don't have to worry about. Let's be sure they know they can depend on *us.*

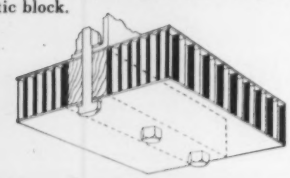
Join

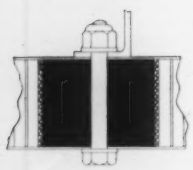
On the job when you need it most

#3
INGENUITY: Key to Successful Honeycomb Sandwich Design

In most actual honeycomb sandwich applications the success of the design is a direct measure of the ingenuity of the designer. The reason for the heavy dependence on the designer's resourcefulness is that the details of such light weight composite materials require many unusual innovations in order to carry in-loads which are higher than can be normally sustained by the overall structure.

Typical of such problems is the design of an attachment point, or tie-down fitting, in the middle of a sandwich floor. Figure 1 illustrates a satisfactory design wherein the material tie-down fitting is accomplished through a wooden block which distributes concentrated loads created by the fasteners. Figure 2 illustrates another load distribution technique utilizing a molded or poured plastic block.





A large diameter washer under the bolt head will further aid in load distribution.

INFORMATION REQUEST

Send to Hexcel Products Inc. Dept "D-2"
2332 Fourth Street, Berkeley 10, California.

NAME_____

TITLE_____

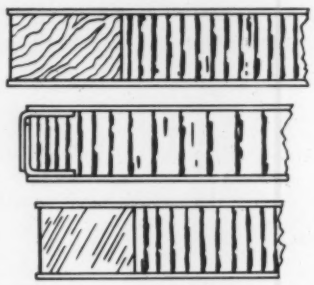
COMPANY_____

STREET_____

CITY_____ ZONE___ STATE_____

Edge Details

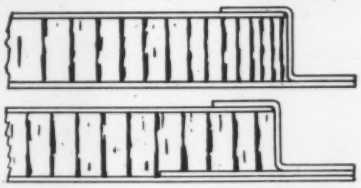
The edges of a sandwich structure are not normally required to be sealed off for environmental purposes since most core materials are resistant to normal atmospheric exposure. It usually is imperative, however, to close the edges off to prevent incidental damage to the core and to provide strengthening of the sandwich to carry edge attachment loads. Sketches of typical edge details are shown in Figure #3.



A simple inspection of the various means shown should provide an idea for a method suitable for a design capable of meeting any specific edge loading.

Adding Strength in Critical Areas

In many designs it is desirable to have the overall light weight of a sandwich structure, but it is still necessary to meet extremely high load requirements in some localized areas. These conditions can be met by using a high density honeycomb in the local area, by adding doublers under the skin, or by the use of various composites of inserts.



These design types are typical of those being used today in designs which permit an improvement in strength-weight ratio of four to ten times.

Such results signal even greater achievements ahead as designers become more intimately familiar with the design opportunities offered by composite honeycomb structures.

Since World War II designers of air and space craft have made ever-increasing use of honeycomb in a great variety of structural and non-structural applications. Honeycomb can be made from almost any material available in continuous web or roll form, e.g., aluminum, glass fabric, cotton, stainless steel, paper, asbestos, titanium. In its cellular configuration, honeycomb is 97% air, 3% material.

Honeycomb has intrinsic qualities of high strength, light weight, high ratio of surface area to volume and other specific properties which depend upon the type of material used. These combinations of properties, which have given honeycomb wide application in air and space craft, offer to designers in industry generally unique opportunities in product design. In the interest of advancing this knowledge of honeycomb, Hexcel, through its research and development staff (the industry's largest), has prepared this informational series. Should you desire additional technical information or copies of others in this series, please complete the information request form on this page. Your request will receive immediate attention.

HEXCEL® PRODUCTS INC.
World leader in honeycomb
Executive Offices: 2332 Fourth Street, Berkeley 10, Calif.
Plants: Oakland and Berkeley, Calif.; Havre de Grace, Md.
Sales Offices: Long Island City, N.Y.; Fort Worth, Texas; Inglewood, Calif.

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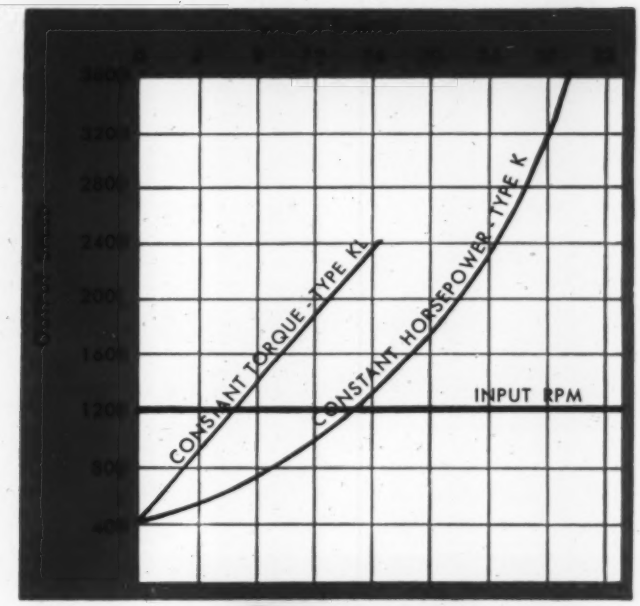
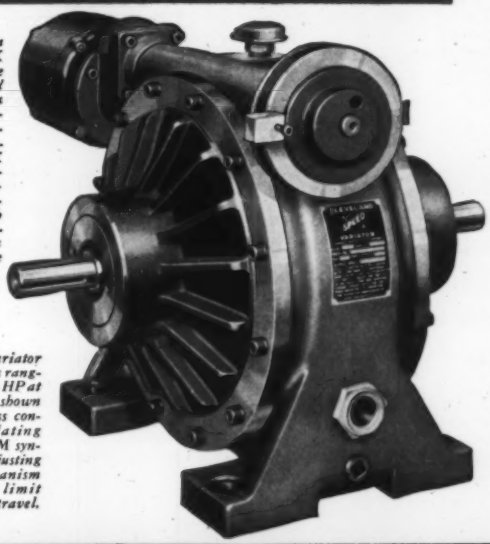


Typical speed regulation curves for the Types K and KL Variators. Type KL offers a linear speed regulating pattern, often an advantage in automatic control applications. Output speed regulation of the Type K Variator follows a geometric progression pattern. Starting at the minimum output speed, each turn of the speed regulating wheel produces a fixed percentage increase in output shaft speed.



The Cleveland Speed Variator is available in 18 models ranging from fractional to 16 HP at 1750 input RPM. Unit shown at right, used in process control, has speed regulating worm driven by 75 RPM synchronous motor, with adjusting shaft indicating mechanism modified to actuate limit switches to prevent overtravel.

CLEVELAND SPEED VARIATOR

Accurately Provides Dependable, Infinitely Variable Speed Control

ANNOUNCED late in 1954, the new Cleveland Speed Variator met instant, enthusiastic acceptance. Engineers and designers of industrial equipment already have put thousands of units into use on such varied equipment as cigarette making machines, textile machinery, metalworking machinery, pharmaceutical equipment, transfer tables, conveyors and experimental and testing equipment of many types.

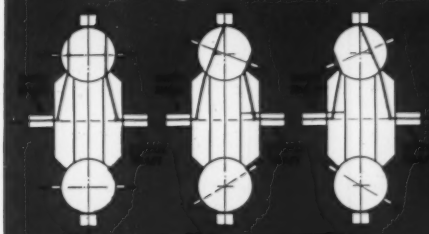
Infinitely variable, the Cleveland Speed Variator gives stepless speed over a full 9:1 range—from ⅓ to 3 times input speed. Output speed can be adjusted by either a hand wheel on the Variator or by manual or automatic remote control.

The Cleveland Speed Variator offers these major advantages:

1. An extremely compact unit with input and output shafts in line and rotating in the same direction.
2. Almost any input speed up to 1800 RPM can be used—either clockwise or counterclockwise rotation.
3. Rated for constant horsepower output over a 9:1 or 6:1 range; or for constant output torque over a 6:1 range.
4. Speeds infinitely variable over entire range of adjustment.
5. No slippage—positive torque response mechanism adjusts in direct proportion to the loads encountered.
6. Long life and minimum maintenance due to absence of belts or complicated linkages.
7. Ample bearing support for overhung pulleys on both input and output shafts.

Write for Bulletin K-200 for detailed description with photographs, sectional drawings, rating tables and specifications.

HOW THE CLEVELAND SPEED VARIATOR WORKS



THE CLEVELAND WORM AND GEAR COMPANY

Speed Variator Division, 3287 East 80th Street, Cleveland 4, Ohio

Subsidiary of Eaton Manufacturing Company

Circle 402 on Page 19

New Repeat Accuracy — the Cutler-Hammer 10316 Precision Limit Switch always trips at the same point of "in" and "out" plunger travel
NO. 10316H89A
OUT
IN
A
B
MUST BE SAME POLARITY

NEW HIGH PRECISION in a NEW PRECISION LIMIT SWITCH

- **LASTS 10 TIMES LONGER**
- **CAN'T TEASE**
- **TRIPS REPEATEDLY AT PRECISELY THE SAME POINT**

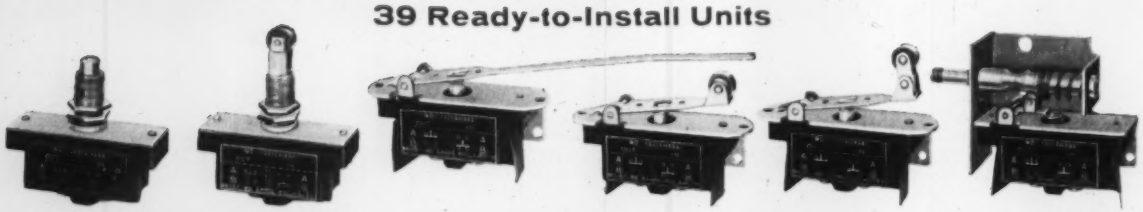
The new 10316 will change your ideas about what an industrial duty precision limit switch can do.

Comparative tests proved the 10316 provides ten times greater life. It could not be teased. And it always fired at exactly the same points of "in" and "out" plunger travel. Prove it yourself! You'll discover a *new high* in electrical and mechanical life, the sureness of repeat action, the utter dependability of the Cutler-Hammer 10316 Precision Limit Switch.

Three dimensionally identical switch bases are available. Double circuit switch is normally open—normally closed. Single circuit switches are either normally open or normally closed. A wide variety of operators, with various individual mountings, provide easy-to-install units meeting practically every type of application.

If you use precision limit switches at all, the 10316 is for you. Know the difference—write for fully explanatory Pub. EA 154-H243 Cutler-Hammer Inc., Milwaukee 1, Wisconsin.

39 Ready-to-Install Units



Plunger Operators for in-line operation with controlled overtravel.

Roller Plunger available for in-line or right angle operation.

6" Lever can be formed on-the-job to satisfy unusual needs.

Roller Lever with either right or left-hand operator. Operates in both directions.

1-Way Roller Lever operates in one direction, by-passes in the other.

Cabinet Door Perfect control panel safety interlock . . . available with single or double contact block operators.

CUTLER-HAMMER CONTROL

CUTLER-HAMMER

Cutler-Hammer Inc., Milwaukee, Wis. • *Division:* **Airborne Instruments Laboratory.** • *Subsidiary:* **Cutler-Hammer International, C. A.**

Associates: Canadian Cutler-Hammer, Ltd.; Cutler-Hammer Mexicana, S. A.; Intercontinental Electronics Corporation.

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